BIOLOGICAL EVALUATION for COOK INLET BELUGA WHALE DESIGNATED CRITICAL HABITAT and EPA's PROPOSED APPROVAL of ALASKA's REVISED MIXING ZONE REGULATION

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1.0 Introduction

Section 7(a) of the Endangered Species Act ("ESA"), 16 U.S.C. Section 1536(a), requires that federal agencies review their actions to ensure that they are not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of designated critical habitat of each such species. A biological evaluation provides an analysis of the potential effects of a proposed federal agency action on any proposed and listed species or the designated critical habitat of any such species based on the best scientific or commercial information available.

This is an addendum to a previous biological evaluation which addressed the Environmental Protection Agency's (EPA) proposed approval of Alaska's revised mixing zone rule (18 AAC 70.240) and potential effects to the Cook Inlet beluga whale, and has been prepared to assist the EPA and the National Marine Fisheries Service (NMFS) in carrying out their activities pursuant to the ESA as they pertain to the Cook Inlet beluga whale's designated critical habitat. Proposed critical habitat for the Cook Inlet beluga whale was not evaluated in EPA's previous biological evaluation. Therefore, the purpose of this addendum is to evaluate whether an EPA approval of Alaska's revised mixing zone regulation is likely to result in adverse effects to designated Cook Inlet beluga whale critical habitat.

1.1 Proposed Action

The proposed federal action that is the subject of this biological evaluation addendum is EPA's approval, in whole or in part, of Alaska's 2006 revised mixing zone rule (18 AAC 70.240). The revised mixing zone rule is part of Alaska's water quality standards (WQS), was adopted by the Alaska Department of Environmental Conservation (ADEC) on February 17, 2006, and was submitted to EPA for review and action in accordance with Section 303(c) of the Clean Water Act (CWA) by letter dated August 14, 2006. EPA is consulting on the entirety of Alaska's revised mixing zone rule.

1.2 Action Area

The action area for EPA's assessment is waters of the United States in Cook Inlet, within the State of Alaska's jurisdiction, that were designated as critical habitat for the Cook Inlet beluga whale by NMFS on April 11, 2011 (76 FR 20180). A map and coordinates for the two areas of Cook Inlet beluga whale critical habitat designated by NMFS are presented in 76 FR 20180;20212-20213 and are codified at 50 CFR 226.220. This action area is a subset of waters delineated by the range distribution of Cook Inlet beluga whales and is significantly smaller than the action area from the previous consultation on the Cook Inlet beluga whale.

Under the CWA, state WQS are to apply to surface waters of the United States that are within a State's jurisdiction. The line of ordinary low water and the line marking the seaward limit of inland waters are known as "baseline." Within the first three nautical miles seaward from the baseline, state boundaries overlap with the territorial seas of the United States. Territorial seas are defined as "the belt of the seas measured from the line of ordinary low water along that portion of the coast which is in direct contact with the open sea and the line marking the seaward limit of inland waters, and extending seaward a distance of three nautical miles" (CWA Section 502(8)). In Cook Inlet, the seaward limit is defined by the southern edge of Kalgin Island.

1.3 Project History

EPA previously consulted with National Marine Fisheries Service (NMFS) on Alaska's 2006 revised mixing zone rule (Revisions to the Mixing Zone Regulations of Alaska's Water Quality Standards Biological Assessment, September 29, 2006). EPA's assessment included conference on the Cook Inlet beluga whale as a candidate species and the consultation and conference were concluded by an August 5, 2008 letter from NMFS. The Cook Inlet beluga whale was subsequently listed as endangered on December 22, 2008 (73 FR 62919), and on April 15, 2009 EPA requested formal consultation on that listing and Alaska's 2006 revised mixing zone rule. That April 15, 2009 request for consultation included an assessment which supplemented EPA's 2006 biological assessment (Cook Inlet Beluga Whale Effects Analysis for Alaska's Mixing Zone WQS Revisions, April 9, 2009). On December 20, 2010, NMFS provided EPA with a non-jeopardy biological opinion on the Cook Inlet beluga whale (Endangered Species Act Section 7 Consultation on the U.S. Environmental Protection Agency's Proposed Approval of the State of Alaska's Mixing Zone Regulation Section, of the State of Alaska Water Quality Standards, NMFS, December 20, 2010).

NMFS published a final rule designating critical habitat for the Cook Inlet beluga whale on April 11, 2011 (76 FR 20180). As described above, this document is an addendum to EPA's 2006 biological evaluation. EPA has not yet taken a CWA action on Alaska's 2006 revised mixing zone rule, and there have been no further revisions to Alaska's mixing zone rule since 2006.

In addition to EPA's September 29, 2006 biological assessment and April 9, 2009 supplemental analysis, EPA provided the following information to NMFS:

1) By letter of 12/12/2007, Jannine Jennings, EPA, to LaVerne Smith, USFWS and Doug Mecum, NMFS:

- A 12/11/2007 response "memo" to information requests from USFWS
- Ten maps showing the location of NPDES discharges in Alaska, by discharge category (1-10), i.e., Seafood/aquaculture, Forest products, Air/Sea transport, Miscellaneous, Mining (non-placer), Oil & Gas, Water supply, Wastewater treatment, Construction and development, and Placer mining.
- A spreadsheet with NPDES discharge location, receiving water, and mixing zone info.
- An "Envirofacts parameters" spreadsheet with additional NPDES info.
- Tables for discharge categories 1, 5, 6, and 8, identifying mixing zone size and dilution factor by permitted parameter.
- Spreadsheets presenting the results of mixing zone pollutant exposure analyses for Seller Eider, Humpback whale, Steller sea lion, Northern Sea Otter, and Albatross.
- The wildlife methodology used for the mixing zone pollutant exposure analyses.

2) By email of 11/18/2009, William Beckwith, EPA to Kate Savage, NMFS:

- A spreadsheet with discharge monitoring/DMR data for facilities with individual NPDES permits for discharges to Cook Inlet.
- A guide to the codes and abbreviations used in the DMR data spreadsheet.
- Links to the EPA website for the Cook Inlet Oil & Gas general permit (AKG315000) and the Seafood general permit (AKG520000).

Additional history related to EPA's proposed action, including the development of Alaska's mixing zone rule and EPA's earlier coordination with NMFS (2004 – 2006) is presented in EPA's September 29, 2006 biological assessment (Sections 1.1 and 1.2).

EPA has also completed an Essential Fish Habitat consultation on Alaska's 2006 revised mixing zone rule, under the Magnuson-Stevens Fishery Conservation and Management Act, as amended by the Sustainable Fisheries Act of 1996 (Public Law 104-267).

1.4 Physical or Biological Features of Cook Inlet Beluga Whale Critical Habitat

As discussed in the history section, NMFS published a final rule designating critical habitat for the Cook Inlet beluga whale on April 11, 2011 (76 FR 20180). With the designation of critical habitat, NMFS established the following physical or biological features (PBFs) essential to the conservation of the Cook Inlet beluga whale (69 FR 20180;20214):

> (1) Intertidal and subtidal waters of Cook Inlet with depths <30 feet (MLLW) and within 5 miles of high and medium flow anadromous fish streams.
> (2) Primary prey species consisting of four species of Pacific salmon (Chinook, sockeye, chum, and coho), Pacific eulachon, Pacific cod, walleye pollock, saffron cod, and yellowfin sole.
> (3) Waters free of toxins or other agents of a type and amount harmful to Cook Inlet beluga whales.
> (4) Unrestricted passage within or between the critical habitat areas.
> (5) Waters with in-water noise below levels resulting in the abandonment of critical habitat areas by Cook Inlet beluga whales.

EPA notes that the designation of critical habitat for the Cook Inlet beluga whale at 69 FR 20180;20214 used the term primary constituent element (PCE). The phrase physical or biological features (PBF) is now used under ESA, rather than PCE. Therefore, PBF is used in this addendum.

1.5 The Federal WQS Framework, including EPA's Regulation and Guidance Addressing Mixing Zones

In accordance with the CWA and the federal WQS regulation at 40 CFR Part 131, states and authorized tribes may include mixing zone provisions in their WQS. Regulatory mixing zones are areas where mixing of a discharge with its receiving water takes place and certain water quality criteria are allowed to be exceeded. The federal WQS framework is briefly described in EPA's September 29, 2006 biological assessment, as is EPA's WQS regulation and guidance specific to mixing zones. Since that time EPA has revised its WQS regulation at 40 CFR Part 131 (80 FR 51020, August 21, 2015) and updated Chapter 5 of its WQS Handbook addressing mixing zones (EPA 820-B-14-004, September 2014); however, there has been no substantive change in EPA's regulation or guidance addressing mixing zones. EPA's WQS Handbook also provides detailed discussion of other aspects of the water quality standards program.

1.6 Alaska's Mixing Zone Rule

Alaska's revised mixing zone rule is found as 18 AAC 70.240. In revising its mixing zone regulation, ADEC repealed 18 AAC 70 Sections 245, 250, 255, 260, and 270 of its former regulation and consolidated the revised regulation in 18 AAC 70.240. A summary of Alaska's revised mixing zone rule is presented below and the full text of 18 AAC 70.240 is included in Appendix A of this addendum.

Section 18 AAC 70.240(a) establishes the authority for ADEC to authorize mixing zones in which water quality criteria may be exceeded, places the burden of demonstrating that a mixing zone would comply with 18 AAC 70.240 on the applicant, and makes it clear that mixing zones are not entitlements by specifying that ADEC has the option to approve, approve with condition, or deny a mixing zone application.

Section 18 AAC 70.240(b) contains a list of factors ADEC is to consider in determining whether to authorize a mixing zone, which include biological, chemical, and physical characteristics of the receiving water; effluent characteristics; the effects that a discharge would have on the receiving water's use, including cumulative effects of multiple sources, point and nonpoint; and any other factors ADEC finds must be considered to determine whether a mixing zone will comply with 18 AAC 70.240.

Section 18 AAC 70.240(c) contains a list of conditions upon which ADEC's approval of a mixing zone is contingent. This section provides that minimum treatment requirements of state and federal law are to be applied to discharges, and that designated and existing uses and the biological integrity of the water body are to be protected. There are also a number of "the mixing zone will not" provisions that are more specific to the protection of critical resources. Those provisions prohibit acute and chronic toxicity outside of a mixing zone; protect existing water supply and contact recreation uses; protect established processing activities or established commercial, sport, personal-use, or subsistence fish and shellfish harvesting; prohibit reduction of fish and shellfish populations; prohibit permanent or irreparable displacement of indigenous organisms; prohibit adverse effects to threatened or endangered species except as authorized under ESA; and prohibit mixing zones from forming a barrier to migratory species or fish passage.

Section 18 AAC 70.240(d) contains a list of conditions for in-zone water quality (i.e., the quality of water within a mixing zone) upon which ADEC's approval of a mixing zone is contingent. These provisions prohibit pollutants that bioaccumulate, bioconcentrate, or persist above natural levels in sediments, water, or biota to significantly adverse levels; settle to form objectionable deposits (except as authorized under 18 AAC 70.210); produce floating debris, oil, scum, etc., that form nuisances; cause lethality to passing organisms; or that exceed acute aquatic life criteria at and beyond the boundaries of an initial acute mixing zone.

Section 18 AAC 70.240(k) provides that mixing zones are to be as small as practicable and specifies mixing zone "size limitations" for various waterbody types. Those size limitations are allowed to be increased, however, upon demonstration that it can be done safely.

Section 18 AAC 70.240(m) specifies that if a mixing zone is having a significant unforeseen adverse environmental effect, ADEC will terminate, modify, or deny renewal of the permit or certification authorizing the mixing zone.

Section 18 AAC 70.240(l) specifies receiving water design flows for streams rivers, and other flowing fresh waters that are to be used in calculating maximum pollutant discharge limitations, and Sections 18 AAC 70.240(e), (f), (g), (h), (i), (j), (n), (o), and (p) are related to spawning areas and mixing zones in lakes, streams, rivers, and other flowing fresh waters. These provisions are not relevant to the area designated as critical habitat for Cook Inlet beluga whales, but are included with the complete text of Alaska's revised mixing zone rule in Appendix A.

Select provisions of Alaska's revised mixing zone rule, that EPA believes are most pertinent in considering the impacts on the PBFs of Cook Inlet beluga whale critical habitat, are presented below in full text.

> (c) The department will approve a mixing zone, as proposed or with conditions, only if the department finds that available evidence reasonably demonstrates that
> (2) designated and existing uses of the waterbody as a whole will be maintained and protected;
> (3) the overall biological integrity of the waterbody will not be impaired; and
> (4) the mixing zone will not
> (A) result in an acute or chronic toxic effect in the water column, sediments, or biota outside the boundaries of the mixing zone;
> (D) result in a reduction in fish or shellfish population levels;
> (E) result in permanent or irreparable displacement of indigenous organisms;
> (F) adversely affect threatened or endangered species except as authorized under 16 U.S.C. 1531 - 1544 (Endangered Species Act); or (G) form a barrier to migratory species or fish passage.
>
> (d) The department will approve a mixing zone, as proposed or with conditions, only if the department finds that available evidence reasonably demonstrates that within the mixing zone the pollutants discharged will not
> (1) bioaccumulate, bioconcentrate, or persist above natural levels in sediments, water, or biota to significantly adverse levels, based on consideration of bioaccumulation and bioconcentration factors, toxicity, and exposure;
> (3) settle to form objectionable deposits, except as authorized under 18 AAC 70.210;
> (4) produce floating debris, oil, scum and other material in concentrations that form nuisances;
> (7) cause lethality to passing organisms; or
> (8) exceed acute aquatic life criteria at and beyond the boundaries of a smaller initial mixing zone surrounding the outfall, the size of which shall be determined using methods approved by the department.

ADEC also provided implementation guidance for its 2006 mixing zone regulation, transmitted to EPA by letter on February 13, 2009 (Implementation Guidance: 2006 Mixing Zone Regulation Revisions, February 3, 2009, referred to hereafter as Alaska's mixing zone implementation guidance). Rather than providing comprehensive guidance, the guidance focuses on significant revisions to Alaska's rule. Where applicable, EPA referred to Alaska's mixing zone implementation guidance to inform how Alaska interprets and intends to implement its revised mixing zone rule.

2.0 Environmental Baseline

The environmental baseline for Cook Inlet was previously described by EPA and NMFS in the September 29, 2006 Biological Evaluation and December 20, 2010 Biological Opinion for the ESA consultation on the species listing for the Cook Inlet beluga whale. More recent descriptions of the environmental baseline for Cook Inlet exist in several documents, including Biological Opinions issued by NMFS as recently as 2016, NMFS's 2015 draft recovery plan for the Cook Inlet beluga whale, and EPA's 2013 Biological Evaluation for the Cook Inlet Oil and Gas Exploration National Pollutant Discharge Elimination System General Permit:

• ExxonMobil Alaska LNG LLC LNG Geophysical & Geotechnical Program in the Waters of Cook Inlet, 2015-2016, ESA Section 7(a)(2) Biological Opinion Revision, NMFS Alaska Region, AKR-2015-9474, March 11, 2016.

• Port of Anchorage Test Pile Project Associated Proposed Issuance of Incidental Harassment Authorization and NWP Verification, ESA Section 7(a)(2) Biological Opinion, NMFS Alaska Region, AKR-2016-9513, March 2, 2016.

• Recovery Plan for the Cook Inlet beluga Whale (*Delphinapterus leucas*), NMFS Alaska Region, Draft, May 15, 2015.

• Cook Inlet Oil and Gas Exploration National Pollutant Discharge Elimination System General Permit, Biological Evaluation, USEPA Region 10, October 2013.

To update the environmental baseline information for this addendum to its biological evaluation, EPA is incorporating descriptions of the Cook Inlet environmental baseline in the above referenced documents by reference. Additional information relevant to the environmental baseline in presented in the following sections.

2.1 Status of Water Quality in Cook Inlet

ADEC's list of impaired waters does not include any portions of Cook Inlet. A few streams that are tributary to Cook Inlet, including the lower portion of Ship Creek in Anchorage, are listed as impaired for fecal coliform bacteria. Ship Creek is also listed for petroleum hydrocarbons and oil & grease (Alaska's Final 2010 Integrated Water Quality Monitoring and Assessment Report, July 15, 2010, as approved by EPA on September 30, 2010; Alaska's Proposed Final 2012 Integrated Water Quality Monitoring and Assessment Report, submitted to EPA on December 30, 2013, not yet approved).

2.2 Point Source Discharges to Cook Inlet

A current list of Cook Inlet point source discharges with mixing zones permitted under the Alaska Pollutant Discharge Elimination System (APDES)/National Pollutant Discharge Elimination System (NPDES) is included in Appendix B (information provided by ADEC on 12/5/2016, with some formatting and additional information provided by EPA). The number of permitted discharges and the characteristics of those discharges has not changed significantly since EPA's previous biological evaluation.

Information provided by ADEC indicates that there are approximately 45 active permits that authorize point source discharges with mixing zones in Cook Inlet; including 25 oil and gas, 6 wastewater related (including municipal wastewater), and 14 seafood processing facilities. There are multiple mixing zones authorized for some of these facilities and some facilities (seafood processing vessels) are authorized to discharge into mixing zones at multiple locations. EPA estimates that the area authorized for mixing zones is 600 - 700 km^2, or approximately 2 percent or less of total Cook Inlet beluga whale designated critical habitat.

2.3 Cook Inlet Beluga Whale Behavior and Prey Species

2.3.1 Seasonal Movements

Tracking studies demonstrate that belugas travel along the shorelines in Cook Inlet and focus their hunting efforts on rivers and fish-bearing streams that are used by salmonids for spawning. Rugh (2010) used the data collected by NOAA and Alaska Department of Fish and Game for three periods of time 1978 to 1979, 1993 to 1997 and 1998 to 2008 to assess the species movement over time and document their range constriction. They determined that the whales have consistently moved north into upper Cook Inlet while continuing to use the Susitna River Delta. According to data collected from 1993 to 1997 beluga whales were using 51 percent of their original range and from 1998 to 2008 this use had dropped to 39 percent. According to Rugh et al. (2010) this species has "essentially disappeared" from formerly used habitat in middle and lower Cook Inlet.

NMFS tracking study and other efforts have determined that over time beluga whales in Cook Inlet are now gathering in shallow areas near river mouths in the upper inlet near Anchorage (Rugh et al. 2000, Hobbs et al. 2005, Goetz et al. 2012). Goetz et al (2012) tagged and monitored the movements of 25 beluga whales in Cook Inlet from 1999 to 2003. They monitored movement (n=14) and diving depth (n=11) including during the winter months. (Goetz et al. 2012). The authors concluded that overall belugas spend the majority of their time in upper Cook Inlet, north of East and West Foreland. Specifically, they observed whales foraging in Chickaloon Bay, Susitna Delta, Knik Arm, Turnagain Arm and Trading Bay. The whale's movements differed somewhat on a seasonal basis; from June to November they spent the most time in Knik Arm and Chickaloon Bay and in December to May they ventured farther south to the area above East and West Foreland. Overall beluga whales spent 0.2 percent of their time in lower Cook Inlet.

The whales preferred shallow inshore waters throughout the year, but the presence of sea ice between December and May may keep them from accessing the coastal areas (Goetz et al. 2012). Belugas prefer deeper water (greater than 25m) from December to May and shallower water (less than 25 m) in June to November (Goetz et al. 2012). According to the data collected, the whales dove to deeper depths in the North Foreland and in lower Cook Inlet, while the longest mean dive durations occurred in the North Foreland in Knik Arm (Goetz et al. 2012). However, the authors would have expected the whales to dive deeper in lower Cook Inlet considering the bathymetry (Goetz et al. 2012). The mean diving depth of belugas whales in lower Cook Inlet ranged from 1.8 ± 3.3 m from June to November to 10.2 ± 13.7 m from May to December, with and overall mean of 7.2 ± 11.9 m (Goetz et al. 2012).

Hobbs et al. (2005) tracked the movements of 14 belugas using satellite telemetry between July and March between 2000 and 2003. They determined that the whales remained in upper Cook Inlet between late autumn and moved to the mid-Inlet offshore waters during the winter. In the summer and early fall the whales concentrated at river mouths or bays to take advantage of eulachon (*Thaleichthys pacificus*) and Pacific salmon runs (Hobbs et al. 2005). The whales moved from 11 km to 30 km on a daily basis. The home range size varied depending on the season, with the smallest in August (982 km^2) increasing to a maximum in winter (5,000 km^2).

In summary, beluga whales are primarily found in upper Cook Inlet, and they spend a small percentage of their time in the lower Inlet. Previously used habitats in mid and lower Cook Inlet are rarely used. They prefer shallow inshore water and tend to travel along the shorelines in Cook Inlet and focus their hunting efforts on rivers and fish-bearing streams. The whales have a larger home range in winter than summer and dive to deeper depths in lower Cook Inlet.

2.3.2 Overview of Seasonal Feeding Behavior

Cook Inlet belugas feed on a wide variety of prey species, focusing on specific species when they are seasonally abundant. The following is a summary of seasonal feeding behavior.

<u>Spring:</u> In Spring eulachon (Thaleichthys pacificus) and gadids (i.e. cod species) are preferred prey (Hobbs et al. 2008). Eulachon begin spawning migration into the Cook Inlet in spring and are very abundant in several Cook Inlet river systems.

<u>Late spring-summer:</u> Beluga diet shifts to salmon as runs of Pacific salmon (Oncorhynchus spp.) enter the inlet. Both smolt and adult salmon concentrate at river mouths and adjacent intertidal mudflats to osmoregulate during their emigration and immigration, respectively. Five Pacific salmon species: Chinook (O. tshawytscha), pink (O. gorbuscha), coho (O. kisutch), sockeye (O. nerka), and chum (O. keta) spawn in rivers throughout Cook Inlet (Moulton 1997, Moore et al. 2000). Species abundance and migration timing varies by river system.

<u>Fall:</u> As anadromous fish runs begin to diminish, belugas consume the fish species found in nearshore bays and estuaries. These included the same cod species observed in the spring diet and other benthic species such as Pacific staghorn sculpin (*Leptocottus armatus*), starry flounder (*Platichthys stellatus*) and yellowfin sole (*Limanda aspera*). Pacific staghorn sculpin are commonly found near shore in bays and estuaries on sandy substrate (Eschmeyer et al. 1983). Flatfish move into deeper water in the winter as coastal water temperatures cool (though some may occur in deep water year-round) (Morrow 1980). As late as October, belugas continued to use Knik and Turnagain Arm and Chickaloon Bay, but some also ranged into the lower Inlet south to Chinitna Bay, Tuxedni Bay, and Trading Bay (MacArthur River) in the fall (Hobbs et al. 2005).

<u>Late Fall-winter:</u> In November, belugas moved between Knik, Turnagain Arm, and Chickaloon Bay, similar to patterns observed in September (Hobbs et al. 2005). Belugas are likely feeding opportunistically on gadids, flounder and other species. By December, belugas were distributed throughout the upper to mid-Inlet. From January into March, belugas moved as far south as Kalgin Island and slightly beyond in central offshore waters. Belugas also made occasional excursions into Knik and Turnagain Arm in February and March in spite of ice cover greater than 90% (Hobbs et al. 2005).

<u>Winter: (</u>December through March). The primary prey species of the Cook Inlet beluga whale, salmon and eulachon, are absent from the Cook Inlet in winter. As presence of these species declines, beluga winter diet diversifies and they are reported to spend more time feeding at deeper depths. Limited information on winter diet of belugas is available. Dive data from belugas tagged with satellite transmitters suggest that during the winter whales are feeding in deeper waters (Hobbs et al. 2005), possibly on such prey species as flatfish, cod, sculpin, and pollock.

2.3.3 Diet/Prey Preferences by Season

Beluga diet/prey preferences is based on several types of information. Stomach content analyses are the primary information. However, these data are somewhat limited as the most comprehensive analysis of stomach contents includes just 18 stomachs with none representing the winter time period.

Other supporting data are from studies on fish species presence and abundance to estimate likely beluga prey availability at various seasons. These data are coupled with beluga seasonal movement data, and observations by local people to present a general picture of the Cook Inlet beluga whale's seasonal diet/prey preference.

Early research from the 1950s describes the Cook Inlet beluga whale's summer diet as consisting of five salmon species, smelt, flounder, sole, sculpin blenny, lamprey, two types of shrimp, and mussels (NOAA 1976). More recent literature confirms salmon, eulachon, and gadids as the most abundant prey in the Cook Inlet beluga whale diet.

Quakenbush et al. (2015) conducted a comprehensive review of Cook Inlet beluga whale stomach contents. A total of 53 stomachs from the Cook Inlet were analyzed. From 1992-2001, 24 stomachs contents were visually inspected. Of these, seven were empty and the remaining contained eulachon and Chinook. Invertebrates were not reported. A more quantitative analysis was possible on 28 Cook Inlet Beluga stomachs collected March through November 2002-2012 where all identifiable prey items were enumerated. Of the 28 stomachs analyzed, 10 were empty, 17 contained fish, 9 contained fish and invertebrates, and one contained only invertebrates. A total of twelve fish species and eight invertebrate species were identified. The frequency of occurrence of fish species identified from these 17 stomachs is shown in Table 2.3.1 [Table 1 of Quakenbush et al. (2015)]. Invertebrates found the stomachs were primarily shrimp (39% frequency of occurrence), polychaetes (11%), and amphipods (11%). It was noted by Quakenbush et al. (2015) that many of the invertebrates and possibly some of the fish species found in the stomachs of belugas may be the result of secondary ingestion.

Table 2.3.1 - Frequency of occurrence of fish identified from Cook Inlet beluga whale stomach contents collected March-November 2002-2012. (Source: Quakenbush et al. 2015).

Taxon	*Frequency of occurrence (%)*[1]	*Comment*
All Catostomidae	**6**	
Longnose sucker (*Catostomus catostomus*)	6	Only freshwater fish found
All Osmeridae	**11**	
Pacific eulachon (*Thaleichthys pacificus*)	11	
All Salmonidae	**67**	Largest fish found
Coho Salmon (*O. kisutch*)	28	Ave length 62 cm
Chinook Salmon (*O. tshawytscha*)	11	
Chum Salmon (O. *keta*)	28	Ave. length 60 cm
All Gadidae	**39**	
Saffron cod (*Eleginus gracilis*)	22	
Walleye pollock (*Theragra chalcogramma*)	17	
Pacific cod (*Gadus macrochephalus*)	6	
All Cottidae	**6**	
Pacific staghorn sculpin (*Leptocottus armatus*)	6	
All Stichaeidae	**6**	
Slender eelblenny/snake prickleback (Lumpenus spp.)	6	
All Pleuronectidae	**11**	
Starry flounder (Platichthys stellatus)	6	
Yellowfin sole (Limanda aspera)	6	
All other unidentified fish	**11**	

1. Percent frequency of occurrence is the number of stomachs that contained a fish taxon divided by the total number of stomachs that contained prey (n=18) X 100. Note only 17 of the 18 stomachs with contents analyzed contained fish.

Overall, salmon had the greatest percent frequency of occurrence (67%) of the prey species found in the stomachs of Cook Inlet belugas, followed by cod (39%), smelt (11%), and flounder (11%). Prey selection likely depends on the size of the whale. Belugas are sexually dimorphic with males being larger than females of the same age. Males have been found to consume larger fish than females and young whales consume significantly smaller prey items than adults (Seaman et al. 1982). Quakenbush et al. (2015) notes since belugas swallow their prey whole, prey size is limited by size of the individual's esophagus.

The fish species available for Beluga whales in the upper Cook Inlet during the non-winter months was estimated by Houghton et al. (2005a) using recent Knik Arm fish survey data and past data (early 1980s, Dames and Moore as cited by Houghton 2005a see page 48). From these estimates the author extrapolated the species most likely to comprise the majority of beluga diets by month from April to November (Table 2.3.2, from Houghton 2005a). Saffron cod are available in every month except July. The author notes that more fish population studies in beluga feeding areas are needed to confirm the beluga diet in Knik Arm.

Table 2.3.2 - Likely beluga diet in Knik Arm during non-winter months (Source: Houghton 2005a).

Month	Fish species
April	eulachon, saffron cod
May	eulachon, Chinook salmon, saffron cod
June	Chinook salmon, saffron cod (questionable)
July	Pink, chum, sockeye, and coho salmon
August	Coho salmon, saffron cod
September	Saffron cod, longfin smelt (*Spirinchus Thaleichthys*)
October	Saffron cod, longfin smelt
November	Saffron cod

Stomach samples from Cook Inlet belugas are not available for winter months thus insight into their diet and prey preference can only be inferred from possible prey species that are present in the winter months. Saupe et al. (2014) assessed winter prey availability for Cook Inlet by collecting bottom and midwater trawl samples in October and April (bracketing the winter period). In October sampling, the mean biomass density of non-sessile animals was dominated by starry flounder, spiny dogfish (*Squalas acanthias*), jellyfish (Cyanea sp.), sevenspine bay shrimp (*Crangon septemspinosa*), Pacific halibut (*Hippoglossus stenolepis*), walleye pollock (*Theragra chalcogramma*), and Pacific tomcod (*Microgadus proximus*). In the April sampling, mean biomass for non-sessile animals was dominated by starry flounder followed by eulachon, sevenspine bay shrimp, Pacific tomcod, and Pacific sandfish (*Trichodon trichodon*). Assuming no sampling bias, Saupe et al. (2014) had made conclusions regarding winter Cook Inlet beluga feeding, including: 1) prey availability in winter is very low in most of study area; greatest in southeast study area where oceanic influence is stronger, 2) individual body sizes of most potential prey are small, and 3) given low density and small prey, belugas may not be able to acquire a maintenance ration from study area during winter.

As noted by Saupe et al. (2014), other fish species have been collected in upper Cook Inlet and can potentially comprise the beluga diet including (but not limited to) the rock sole (*Lepidopsetta bilineata*), Pacific staghorn sculpin (*Leptocottus armatus*), threespine stickleback (*Gasterosteus aculeatus*), walleye pollock, capelin (*Mallotus villosus*), Pacific sandlance (*Ammodytes hexapterus*), pacific sandfish, Arctic lamprey (*Lampetra japonica*), threespine stickleback (*Gasterosteus aculeatus*) and ninespine stickleback (*Pungitius pungitius*) (Houghton et al. 2005a, 2005b, Moulton 1997). During the spring, Native Alaskans describe Cook Inlet belugas feeding on steelhead trout (Oncorhynchus mykiss), freshwater fish such as whitefish (*Coregonus oidschian*), northern pike (*Esox lucius linnaeus*), and grayling (*Thymallus arcticus*), and other marine fish such as Pacific tomcod (Hobbs et al. 2008).

Based on this review of Cook Inlet beluga movement and diet, five species of Pacific salmon (chinook, coho, sockeye, pink, and chum), Pacific eulachon, longfin smelt, Pacific cod, walleye Pollock, saffron cod, and yellowfin sole emerge as the most common/likely species comprising the diet/prey preference of Cook Inlet beluga whales. The presence and life history characteristics of these fish species of the Cook Inlet are described in the next sections. Information on these species has been summarized in various documents including ADF&G 2008, ADF&G (2015b), LGL (2006), PFMC (2005). Houghton et al. (2005a), and Mecklenburg et al. 2002, and Morrow 1980.

2.3.4 Salmonidae - Salmon

Salmon use many rivers and streams of the Cook Inlet (Figure 2.3.1). Major rivers provide migratory paths for spawning adults and outmigrating juveniles. Spawning locations vary by species and size of runs are also variable. Major systems include: west-side rivers, Susitna River and Delta, Little Susitna, Knik Arm streams, Turnagain Arm, Chickaloon River.

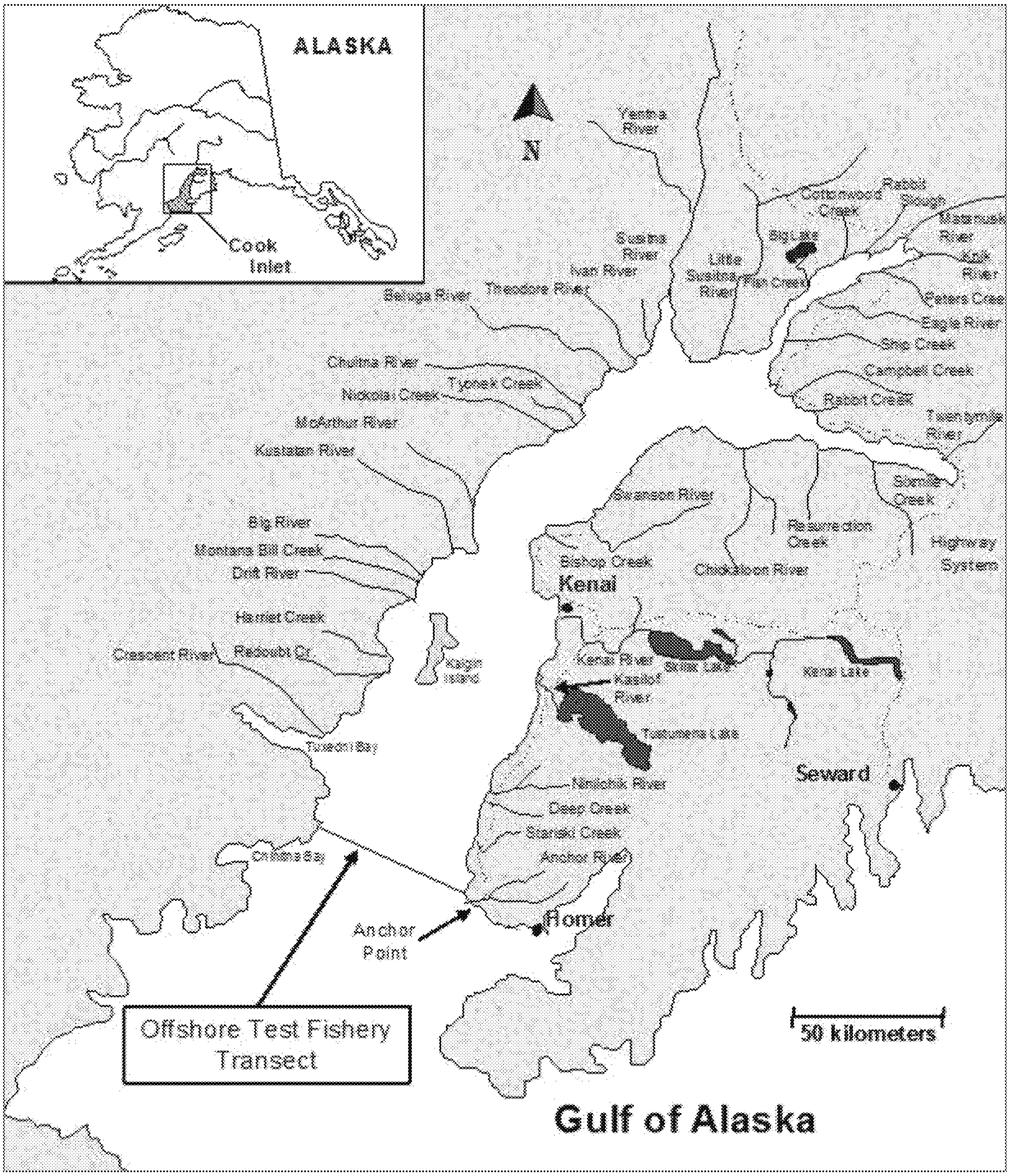

Figure 2.3.1 - Major drainages of the Cook Inlet (Source: Willette 2011).

Adult salmon return from marine habitats to their natal freshwater rivers and streams to spawn in summer and fall. Eggs are laid and develop in gravel substrates, and in later winter salmon eggs incubating in their freshwater redds (gravel substrate nests) hatch as alevins. Alevins emerge from gravel as fry in spring and survive on their yolk (up to 4 months) until they begin to feed on live prey. Fry remain in freshwater for variable amounts of time. Depending on the species and the distance from the spawning area to marine waters, fry may remain in fresh water for only a few days or weeks, or may remain in fresh water for one to two years. As the fry transition to brackish and marine habitats they become smolts. Smolts outmigrate from natal streams into the Cook Inlet beginning in late April through September depending on species. The majority of the salmon outmigration occurs over a short period (late April through early July). Once in the estuarine environment of the Cook Inlet, smolts feed on a variety of prey including amphipods, euphausiids, copepods, decapod larvae, pteropods, and fish (Auburn and Ignell 2000). Rearing juveniles remain in fresh water and estuaries for a total of 1 to 3 years before migrating to the Pacific Ocean where they grow to maturity. The period spent in the upper Cook Inlet estuarine habitat is relatively short, as most juveniles leave the upper Cook Inlet by fall. The ocean phase can last from 1 to 8 years, when salmon return to spawn.

2.3.4.1 Chinook (Oncorhynchus tshawytscha)

Chinook salmon is the largest species of Pacific salmon reaching a length of 160 cm and may weigh 61.2 kg but rarely over 23 kg (Mecklenburg et al. 2002). They range from central California and Japan north to the Chukchi Sea. Chinook fry hatch in spring and most juvenile Chinook remain in freshwater until the following spring when they outmigrate to marine habitats. Smolts feed on plankton and insects in fresh water and on a variety of forage fish species (e.g. herring and sandlance), squid, and crustaceans during their marine phase. Chinook may remain in the ocean for two to six years before returning to spawn. Chinook salmon spawn in rivers throughout south central Alaska, including the Susitna, Beluga, Theodore, and Chuit rivers in Upper Cook Inlet. Chinook salmon enter tributaries on the west side of the Susitna River in May and June, continuing until August (Table 2.3.3).

Adult Chinook salmon are only enumerated at one location in Upper Cook Inlet, at the Deshka River weir (Fox and Shields 2005). Moulton (1997) captured juvenile Chinook salmon smolts along the northwest shore of Upper Cook Inlet in the Susitna, Tyonek, and Trading Bay regions (Moulton 1997). Catch rates peaked in mid-June and mid-July, and no Chinook smolts were caught in September. Chinook smolts captured in June were primarily age-1, while those captured in July were ages-0 and -1. Small numbers of age-2 and -3 juvenile Chinook were also caught. In Knik Arm, Chinook salmon comprised 25.6% of all juvenile salmon captured from April to July 2005 (Houghton et al. 2005a). Peak abundance occurred in June and there was no significant difference in the catch per unit effort among stations throughout the arm. In April, most of the Chinook were age-0 fish from 30 to 40 mm in length. Beginning in May, fish greater than 61 mm dominated the catch, many of which appeared to be of hatchery origin. Multiple cohorts were also present in tow net samples collected in May. Chinook smolt abundance declined in Knik Arm in mid- to late summer.

Table 2.3.3 - Salmon run timing for major Cook Inlet area salmon rivers/streams (Source: ADF&G 2015a, Division of Sport Fish).

Area	Stream	Species	May early	May mid	May late	June early	June mid	June late	July early	July mid	July late	Aug early	Aug mid	Aug late	Sept early	Sept mid	Sept late
Western Cook Inlet	Western C.I. drainages[1]	Chinook			■	■	■	■									
		coho								■	■	■	■	■	■		
Anchorage & Mat-Su	Susitna R. streams	Chinook				■	■	■									
		coho									■	■	■				
		sockeye								■	■	■	■				
		pink							■	■	■	■	■				
		chum								■	■	■	■				
Anchorage & Mat-Su	Yentna R.	Chinook				■	■	■	■								
		coho										■	■	■	■		
Anchorage & Mat-Su	Little Susitna-lower	Chinook			■	■	■	■									
		coho								■	■	■	■				
	Little Susitna-upper	Chinook					■	■	■	■							
		coho										■	■	■	■		
	Little Susitna	sockeye								■	■	■					
Anchorage & Mat-Su	Ship Creek -knik Arm	Chinook	■	■	■	■	■	■	■	■							
		coho[2]									■	■	■	■	■	■	■
		pink							■	■	■	■	■				
Kenai Peninsula	Kenai R.	Chinook-E.		■	■	■	■	■	■								
		Chinook-L.							■	■	■	■					
		coho									■	■	■	■	■	■	■
		sockeye								■	■	■	■				
		pink								■	■	■					
Kenai Peninsula	Russian R.	sockeye-E.					■	■	■	■							
		sockeye-L.								■	■	■	■	■			
Kenai Peninsula	Kasilof R./ Crooked C.	Chinook			■	■	■	■	■	■	■						
		coho									■	■	■	■	■	■	■
		sockeye				■	■	■	■	■	■	■	■	■			
Lower C.I.	Ninilchik / Deep C./Anchor R.	Chinook			■	■	■										
		coho										■	■	■	■	■	

1. Includes Chuitna, Beluga, Theodore, Lewis, McAurhur, and Kustatan rivers.
2. Only run that extends past early September and ends in late October.

2.3.4.2 Coho (*O. kisutch*)

Coho salmon reach 108 cm in length and weigh up to 17.7 kg (Mecklenburg et al. 2002). They spawn in many types of freshwater habitats and are known to migrate long distances. Juvenile coho salmon usually rear from one to three winters in freshwater (ADF&G 2008). Juvenile coho salmon can establish winter territories in freshwater pools and lakes, and may move between brackish estuarine water during spring and summer for feeding and move back to freshwater in the fall (ADF&G 2008). Most coho spend approximately 18 months at sea before returning as adults to natal streams. Jacks return to freshwater after only six months at sea. Adult coho salmon use many river systems in the Upper Cook Inlet. Adult coho salmon return to spawn later than other species and may be found in spawning streams from July through October. The peak of the run in the west-side Susitna area, an early-run stock, is generally in the last week of July (Table 2.3.3).

The Susitna River drainage supports the largest coho stock in Upper Cook Inlet and the largest recreational harvest of coho salmon generally occurs in the Knik and Eastside Susitna Management Units. In Knik Arm, juvenile coho salmon was the second most abundant juvenile salmon species captured in beach seines in 2004, and the most abundant species in 2005 (Houghton et al. 2005a). Coho salmon smolts were captured as early as April and were present in Knik Arm into late November. In both 2004 and 2005, catches of juvenile coho peaked in July, but continued into August. In 2005, coho salmon were distributed throughout Knik Arm but were more abundant on the west side (Houghton et al. 2005a). Several cohorts were present throughout the study period and a relatively high frequency of 101-140 mm coho captured in June 2005 may have resulted from the smolt release from Ship Creek hatcheries. Houghton et al. (2005a) reported that adult coho comprised 0.9% of the total beach seine catch, and that most adult coho were captured in July with smaller numbers in August. In northern Cook Inlet, catch rates of juvenile coho salmon were highest in mid-June and mid-July, and the greatest numbers were caught near the Susitna River delta. Juvenile coho were the only salmon caught in September.

2.3.4.3 Sockeye (*O. nerka*)

Sockeye salmon reach 84 cm in length and weigh up to 7 kg (Mecklenburg et al. 2002). Sockeye salmon range from northern California to the Russian and Canadian Arctic Ocean as well as the western Pacific Ocean south to Japan. Sockeye typically spawn in lakes or rivers associated with lake systems, although some populations spawn in river systems without lakes. Adfluvial populations may spend one to three years in freshwater before returning to the ocean. In systems without lakes, sockeye generally spend less time in fresh water (ADF&G 2008). Landlocked populations (i.e., kokanee) also exist. Sockeye spend one to four years in the ocean (typically 2 or 3) before returning to natal streams to spawn. Adult sockeye salmon are present from June to October in Upper Cook Inlet (ADF&G 2008) (Table 2.3.3).

Juvenile sockeye salmon were caught in Upper Cook Inlet in June and July, but in limited numbers (Moulton 1997). During June, juvenile sockeye were caught throughout the study area in Upper Cook Inlet; in July, they were caught mostly in the eastern and middle portions of the study area (Moulton 1997). Age-1 (one winter in freshwater) was dominant in the June tow samples, but ages-0 and -1 were caught in equal numbers in July. No sockeye salmon were caught in September. In Knik Arm in 2004, juvenile sockeye were the most frequently caught salmon during beach seining from July to November (Houghton et al. 2005a). Catches peaked in August 2004. In 2005, juvenile sockeye catches were low in April and May, peaked in June, and continued in July. Based on length measurements, two cohorts of sockeye (ages-0 and -1) were present in Knik Arm during both years. Juvenile sockeye in Knik Arm appeared to have substantial body growth from July through September 2004.

2.3.4.4 Pink Salmon (*O. gorbuscha*)

Pink salmon are the smallest of the Pacific salmon in North America, with maximum lengths of 76 cm and weights of 6.4 kg (Mecklenburg et al. 2002). Females deposit eggs in freshwater redds or occasionally in intertidal areas. The eggs hatch during the winter and alevins remain in the gravel emerging as fry in late winter or early spring. Fry outmigrate immediately to marine waters. In the ocean, juvenile pink salmon smolts feed on plankton and larval fish, and grow to 10-15cm length by their first winter. They spend a year in the open ocean, returning the following fall to spawn in their natal streams. The two-year hatch to spawn life cycle is generally the shortest of Pacific salmon species. Because pink salmon spawn at two years of age, two separate lines of unrelated fish develop in alternating odd and even year cycles. In the Cook Inlet region, pink runs are even-year dominated. Adult pink salmon return to rivers and streams throughout Upper Cook Inlet. Adults probably feed relatively little in Cook Inlet because they are close to entering their natal stream. Adult pink salmon return to Upper Cook Inlet from early July to mid-August, with Westside Susitna drainages having peak runs in July (Table 2.3.3).

Juvenile pink salmon were the most abundant salmon reported by Moulton (1997) during tow net sampling in Upper Cook Inlet in June and July of 1993, comprising 16.5% of the total catch. Pink salmon were caught in 92% of the tows in June, and comprised approximately 25% of the total catch. Pink salmon numbers decreased in July, when they occurred in only 70% of the tows. Pink salmon were abundant throughout the study area from the East and West forelands to Fire Island near Anchorage. They were most abundant in mid-June near the mouth of the Susitna River. However, a large number of pink salmon was also caught in a single mid-channel tow in mid-July in the eastern portion of the study area. Houghton et al. (2005a) did not capture any pink salmon smolt in Knik Arm during beach seine activities in 2004. Few were expected, as the numbers of pink salmon smolt in even years are much lower. The larger even-year pink runs in Cook Inlet produces a larger number of odd-year outmigrants. In 2005, Houghton et al. (2005a) captured 33 pink salmon smolts (1.9% of all juvenile salmonids). Most pink salmon were captured in May and were young-of-the-year outmigrants between 31 and 40 mm in length. Houghton et al. (2005a) also captured pink salmon smolt during tow net sampling in Knik Arm. Pink salmon smolt were most abundant in May and numbers declined in June and July. Houghton et al. (2005a) reported that adult pink salmon comprised 0.4% of the total beach seine catch and were captured only in July. Juvenile pink salmon captured by Moulton (1997) in June were 36 mm in length. Larger fish were present in July and by mid-July fish ≥ 40 mm outnumbered fish ≤ 40 mm with a mean length of 41.5 mm. Mean lengths of pink salmon were similar in all regions of the study area in June, but in July were greater in the western portions of the study area. Moulton (1997) suggested that the apparent lack of growth in June may have been due to continual emigration of small pink salmon that masked any growth that may have occurred.

2.3.4.5 Chum (*O. keta*)

Chum salmon reach a length of 109 cm and weigh up to 20.8 kg (Mecklenburg et al. 2002). Chum salmon are more widely distributed than other Pacific salmon species and range from California to the Arctic Ocean and Canada. Chum salmon spawn in coastal streams and intertidal areas, but may also travel great distances inland. Chum fry outmigrate to marine waters soon after hatching, usually shortly after ice breaks up from their natal rivers. Chum may not feed before reaching saltwater, thus making marine food resources of special importance. Juvenile chum in Cook Inlet are thought to enter marine water from late May through July. By their first winter, Cook Inlet chum salmon have moved into the Gulf of Alaska and spend three to four years in the ocean before returning to natal streams (ADF&G 2008). Returning chum salmon arrive in Cook Inlet in early July and spawning runs continue through early

August (Table 2.3.3). Their peak run timing is mid-July through mid-August, however their run continues into September (ADF&G 2008).

Chum salmon smolts were the second most abundant salmon reported by Moulton (1997) in Upper Cook Inlet and comprised 10.2% of the total catch. Chum salmon showed a steady increase in size through the study period with mean lengths ranging from 44 mm in early June to 58 mm in mid-July. The growth rate of chum smolt appeared to be greater in July than in June and may have been related to warmer temperatures or to a decrease in the numbers of smolt emigrating from freshwater (Moulton 1997). Houghton et al. (2005a) captured only five juvenile chum in 2004 beach seine sampling and concluded that most chum had probably migrated out of the area before sampling began in late July. Sampling in 2005 began earlier than in 2004 and small numbers of juvenile chum were captured in April with significant increases in May and June. As in 2004, no chum smolts were captured with beach seines in July 2005. Chum salmon smolts were the most abundant salmon captured in tow net sampling in Knik Arm (Houghton et al. 2005a). Chum smolt were most abundant in May and numbers declined in June and July. Houghton et al. (2005a) reported that adult chum salmon composed 0.1% of the total beach seine catch. Adult chum salmon were caught in July.

2.3.4.6 Other Cook Inlet Salmonids

Steelhead (O. mykiss) is a salmonid species that has both freshwater (i.e. resident rainbow trout) and anadromous populations. Anadromous steelhead, like salmon, spend their adult lives in the ocean and move into freshwater streams to spawn. The northwestern limit of the freshwater range of steelhead is the southern tributaries of the Kuskokwim River and the Port Moller region of the Alaska Peninsula. Steelhead are also found in the Gulf of Alaska and the Bering Sea west through the Aleutian Islands to Kamchatka. Steelhead are not abundant in Cook Inlet. Moulton (1997) did not report any steelhead during tow net sampling in Upper Cook Inlet. Houghton et al. (2005a) captured small numbers of steelhead in Knik Arm in July during beach seine sampling.

Dolly Varden (*Salvelinus malma*) occur from the Arctic Ocean to Washington state and Japan and Korea. Dolly Varden are anadromous but freshwater populations are also known. They reach a length of 100 cm and are a popular sport fish. Dolly Varden are generally found in freshwater lakes and streams but are also know to occur in Cook Inlet. Moulton (1997) and Houghton et al. (2005a, 2005b) did not report collection of Dolly Varden in Upper Cook Inlet or in Knik Arm.

2.3.4.7 Summary of Salmon Timing, Distribution, and Abundance

Salmon run timing varies by area and by species. Table 2.3.3 summarizes run timing for Cook Inlet river systems. The following general statements apply:

- Chinook timing brackets the month of June for most runs.
- Coho timing brackets late July and early-mid August.
- Sockeye timing brackets mid-July to mid-August.

Willette (2011) summarized the historical abundance of salmon species in the major river systems of the Cook Inlet based on ADF&G run estimates (Figure 2). The following general statements about salmon abundance in the Cook Inlet by area apply. Note: extensive review of salmon abundance and harvest in the Upper Cook Inlet is available in NMFS (2015).

- West side rivers support small runs of Chinook and moderate runs of coho
- Susitna River supports large runs of all five salmon species
- Little Susitna River supports moderate runs of coho, pink, and chum salmon

- Knik and Turnagain Arm rivers support small runs of all five salmon species
- Kenai River supports large runs of Chinook, coho, and sockeye, and a moderate pink run
- Lower Cook Inlet streams support moderate Chinook runs and small runs of other species

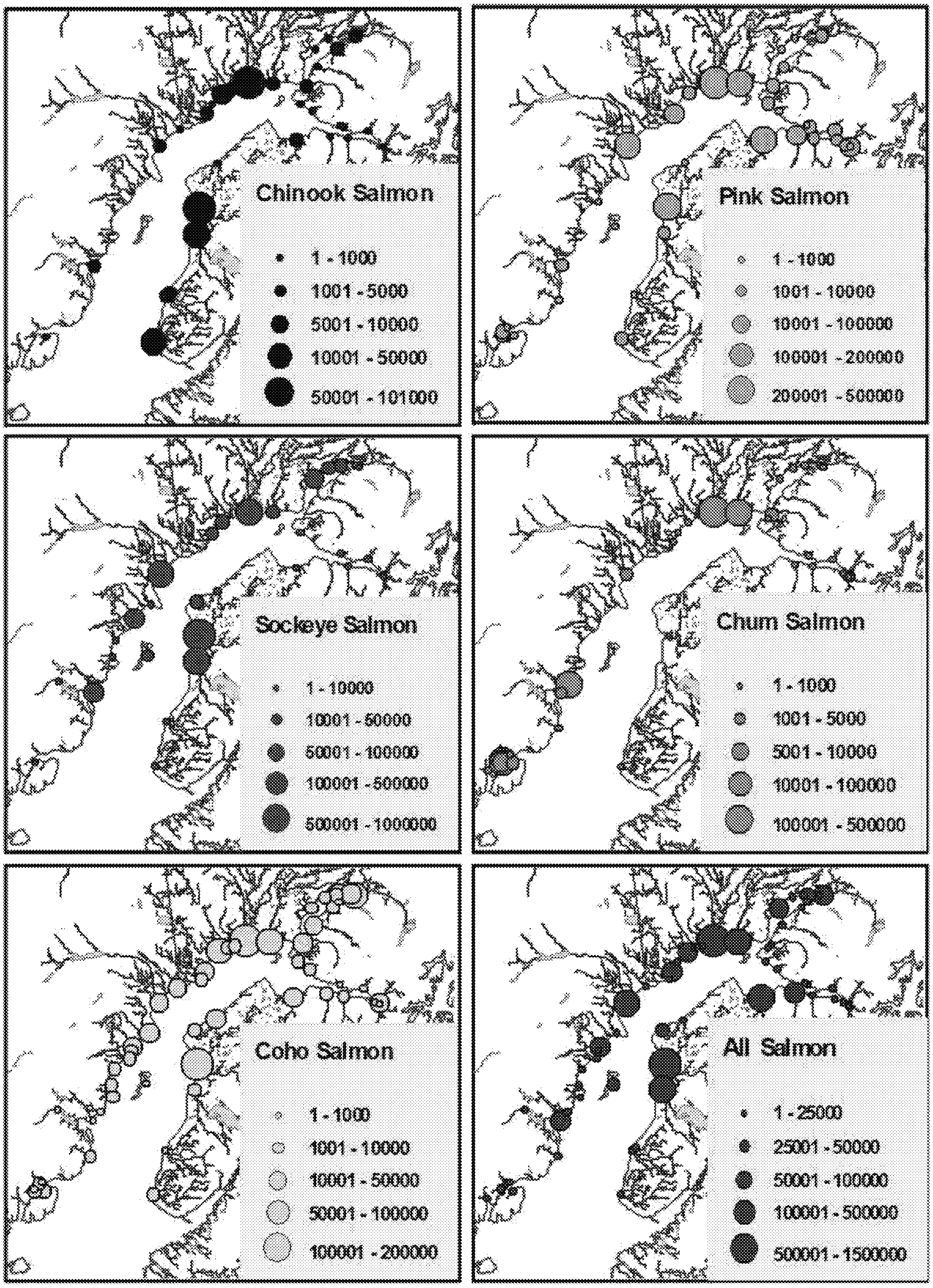

Figure 2.3.2 - Historical mean in-river abundances of Chinook, coho, sockeye, pink, and chum salmon entering the major rivers of the Cook Inlet (Source: Willette 2011).

2.3.5 Gadidae - Cod

Gadids, such as saffron cod (*Eleginus gracilis*) are indigenous to shallow coastal waters and are found near and in rivers within the zone of tidal influence (Morrow 1980, Cohen et al. 1990). Adult cod exhibit seasonal movements: inshore during winter for purposes of spawning and offshore during summer for feeding (Cohen et al. 1990). Both species of cod are opportunistic epibenthic feeders (Cohen et al. 1990). Cod consume polychaetes, shrimp, amphipods, mysids, as well as other fish (e.g., walleye pollock (*Theragra chalcogramma*) and flatfish).

2.3.5.1 Saffron Cod (*Eleginus gracilis*)

Saffron cod occur in the Chukchi and Beaufort seas south through the eastern Bering Sea to southeast Alaska. Saffron cod reach a length of 55 cm. They usually occur in coastal waters to a depth of 60 m but may enter brackish water and rivers to the limit of tidal influence (Mecklenburg et al. 2002). Saffron cod feed on fish and small crustaceans and reach sexual maturity at age three. They spawn in winter and females may produce over 200,000 eggs. The planktonic young hatch from April to June. Saffron cod comprised almost 13% of the total catch during beach seine sampling in Knik Arm (Houghton et al. 2005a, 2005b). Saffron cod comprised only 1.4% of the total catch during Upper Cook Inlet tow sampling (Moulton 1997). Fechhelm et al. (1999) did not report saffron cod in the Chisik Island area. Saffron cod are considered relatively common in the Knik Arm from spring to early winter (Houghton 2005a).

2.3.5.1 Pacific Cod (*Gadus macrocephalus*)

Pacific cod may reach 120 cm in length but the average length in trawl catches is 70 to 75 cm (Mecklenburg et al. 2002). They are distributed in the eastern Pacific Ocean are found from central California to the Bering Sea with unconfirmed reports to the Chukchi Sea. In southcentral Alaska, Pacific cod are found primarily in benthic habitats in water depths ranging from 15 to 550 m. Pacific cod feed on other fish species including walleye pollock, flatfishes, Pacific sandlance, Pacific herring, crab and shrimp. Pacific cod usually spawn in relatively deep water during the winter and move to shallower waters to feed in spring (Cohen et al. 1990). Males become sexually mature at age-2 and females at age-3. Breeding occurs annually and fecundity increases with increasing size of female fish. Eggs develop on the ocean floor and development is affected by temperature. Optimal temperatures for egg development are around 3.5 to 4°C (38.3 to 39.2°F). Larvae are moved by ocean currents and have been found in Cook Inlet in May to July. Larvae feed on copepods and other plankton. Young Pacific cod are often found in shallow coastal waters and move to deeper water with age.

2.3.5.2 Walleye Pollock (*Theragra chalcogramma*)

Walleye pollock ('pollock' from here on) reach 91 cm in length and are an important species in commercial fisheries. Pollock range from the Chukchi Sea south through the Bering Sea and Pacific Ocean to central California and Japan. Pollock are abundant in the Bering Sea and the Gulf of Alaska, and are found in Cook Inlet. In the Gulf of Alaska, pollock are considered as a single stock separate from those in the Bering Sea and Aleutian Islands. Pollock are schooling fish, found on or near the sea bottom as well as at mid-water and near-surface depths, although most catches are found between 50 and 300 m. They are semidemersal distributed from near the surface to depths of 500 m (ADF&G). In late winter/early spring pollock form huge spawning aggregations, including those found in Shelikof Strait and the eastern Bering Sea northwest of Unimak Island. Smaller aggregations in the Gulf of Alaska include those at the Shumagin Islands, the entrance to Prince William Sound, and near Middleton Island. In summer, large aggregations have been found on the east side of Kodiak Island, nearshore along the southern Alaska Peninsula, and other areas. Pollock consistently spawn in the Shelikof Strait area and was the second most abundant groundfish species captured during small-mesh trawl sampling in

Kachemak Bay in 2000 (Gustafson and Bechtol 2005). However, pollock may be less abundant in the upper portions of Cook Inlet. Fechhelm et al. (1999) captured small numbers of pollock during mid-water trawl sampling near Chisik Island in Lower Cook Inlet. Likewise, walleye pollock in Upper Cook Inlet comprised only 2.7% of the total catch during tow net sampling (Moulton 1997), and Houghton et al. (2005a) reported very low pollock numbers in Knik Arm during beach seine sampling. Pollock migrate seasonally between spawning and feeding areas.

In the western Gulf of Alaska, it was found that more than 85% of pollock adults had spawned prior to their earliest sampling in May, indicating that most spawning occurred in March and April. Spawning and pre-spawning fish move high in the water column, forming dense schools. Eggs are Planktonic and are found primarily within 30 m of the surface. Pollock begin to recruit to the spawning population at age two, but age classes four and five contribute most to potential reproduction of the population. Pollock breed yearly.

Juveniles feed on copepods, euphausiids, and fish. In the Southeastern Gulf of Alaska, it was found that small (less than 250 mm) pollock ate mostly planktonic crustaceans, while large pollock (larger than 349 mm) generally ate larger prey, such as shrimp and fish. Cannibalism was observed in only 1% of the stomachs; however, few pollock greater than 450mm have been examined. Pollock enter the fishery around age 3 and live to 15 years or more.

2.3.6 Pleuronectidae - Flounder

Flatfish are typically found in very shallow water and estuaries during the warm summer months and move into deeper water in the winter as coastal water temperatures cool (though some may occur in deep water year-round) (Morrow 1980). The two species that occur in the Cook Inlet that are thought to be preferred prey of Cook Inlet beluga whales are yellowfin sole (*Limanda aspera*) and starry flounder (*Platichthys stellatus*). These are right-eyed flounder species of the family Pleuronectidae.

2.3.6.1 Yellowfin Sole (*Limanda aspera*)

Yellowfin sole occur from the Beaufort Sea through the Aleutian Islands to British Columbia and Korea. They reach a length of 49 cm) and a weight of 1.8 kg (Mecklenburg et al. 2002). Yellowfin sole is a long lived species that is common in Lower Cook Inlet. They are found on the outer shelf in winter but move to shallower water in the summer to spawn. Yellowfin sole feed on benthic and epibenthic invertebrates and fish. Moulton (1997) and Houghton et al. (2005a,b) did not report any yellowfin sole from Upper Cook Inlet or Knik Arm. Fechhelm et al. (1999) reported small numbers of yellowfin sole in the Chisik Island area in August 1997 as well as small numbers of arrowtooth flounder (*Atheresthes stomias*) and butter sole (*Pleironectes isolepis*) in the Chisik Island area.

2.3.6.2 Starry Flounder (*Platichthys stellatus*)

Starry flounder range along the Pacific coast of North America from Alaska to Santa Barbara, California, and from the Bering Sea, Alaska to Japan Orcutt (1950). Starry Flounder are recognized by their dark bands alternating with yellowish-orange bars on the dorsal, anal and caudal fins. They are commonly found on soft bottom (gravel, sand, mud) near shore, often in estuaries. Starry flounder is not considered to be a migratory species. However, adults move inshore in late winter-early spring to spawn near river mouths and sloughs (Orcutt 1950). They move offshore to deeper water in the summer and fall, but these coastal movements are generally less than 5 km (Conley 1977, NOAA 1990). Females begin maturing at 24 cm and 3 years and males 2 years and 22 cm (Garrison and Miller 1982, Hart 1973). Spawning occurs from February to May, peaking in early April British Columbia and the Gulf of Alaska

(Hart 1973). Juveniles are found exclusively in estuaries. Foraging varies with increasing size with diet changing progressively from small copepods to amphipods and annelid worms, and then to crabs, bivalve mollusks, and echinoderms.

2.3.7 Osmeridae – Smelt

2.3.7.1 Eulachon (Thaleichthys pacificus)

Eulachon, also known as hooligan, are a small (<25 cm fork length) forage fish that is seasonally abundant in Cook Inlet (AEA 2013). Eulachon occur from the Bering Sea south through the Aleutians to central California. They are is distinguished from other Alaska smelts by having the front of the dorsal fin begin well behind where the pelvic fin attaches to the body and by having circular grooves on the gill covers. The mouth has moderately developed canine-like teeth, which are lost as the fish approaches maturity.

Eulachon are anadromous and spawn in freshwater. As the spawning season approaches, eulachon gather in large schools off the mouths of their spawning streams and rivers. In Southeast Alaska, the main spawning migration can occur as early as April; while in South central and Western Alaska, spawning generally occurs in May. Eulachon do not strictly return to a particular stream like salmon, but appear to use streams in the general area where they were spawned that have the best habitat conditions. Eulachon use low gradient rivers as they are weak swimmers that cannot negotiate long reaches of high water velocity. Spawning sites are in the lower elevations of the river or stream, but in some rivers with long flat deltas spawning sites may be many miles upstream. Eulachon may migrate as far as 160 km upstream to spawn. Eggs are broadcast over sandy gravel bottoms. Most adults die after spawning. After emergence, they outmigrate to salt water to grow to maturity in the sea. River currents carry newly hatched young to the sea where they feed mainly on copepod larvae and other plankton. Juveniles and adults they feed mainly on euphausiids (krill). After three to six years at sea, they return as adults to spawn.

Eulachon was the fourth most abundant species but was present for only a brief time in early June in Upper Cook Inlet (Moulton 1997). Eulachon comprised 2.1 and 5.1% of the total beach seine catch in Knik Arm studies (Houghton et al. 2005a, 2005b). Moulton (1997) reported that eulachon comprised 14.3% of the total catch in Upper Cook Inlet. Fechhelm et al. (1999) reported that eulachon comprised 26.4 and 44.8% of the total catch near Chisik Island in May and August 1998, respectively. Abookire and Piatt (2005) reported small numbers of eulachon in the Chisik Island area and none in Kachemak Bay or the Barren Islands during mid-water trawl sampling from 1996 to 1999. Eulachon are seasonally abundant in several drainages of the Cook Inlet: the Kenai, Susitna, and 20-Mile rivers. Figure 2.3.3 shows eulachon spawning areas in the Cook Inlet.

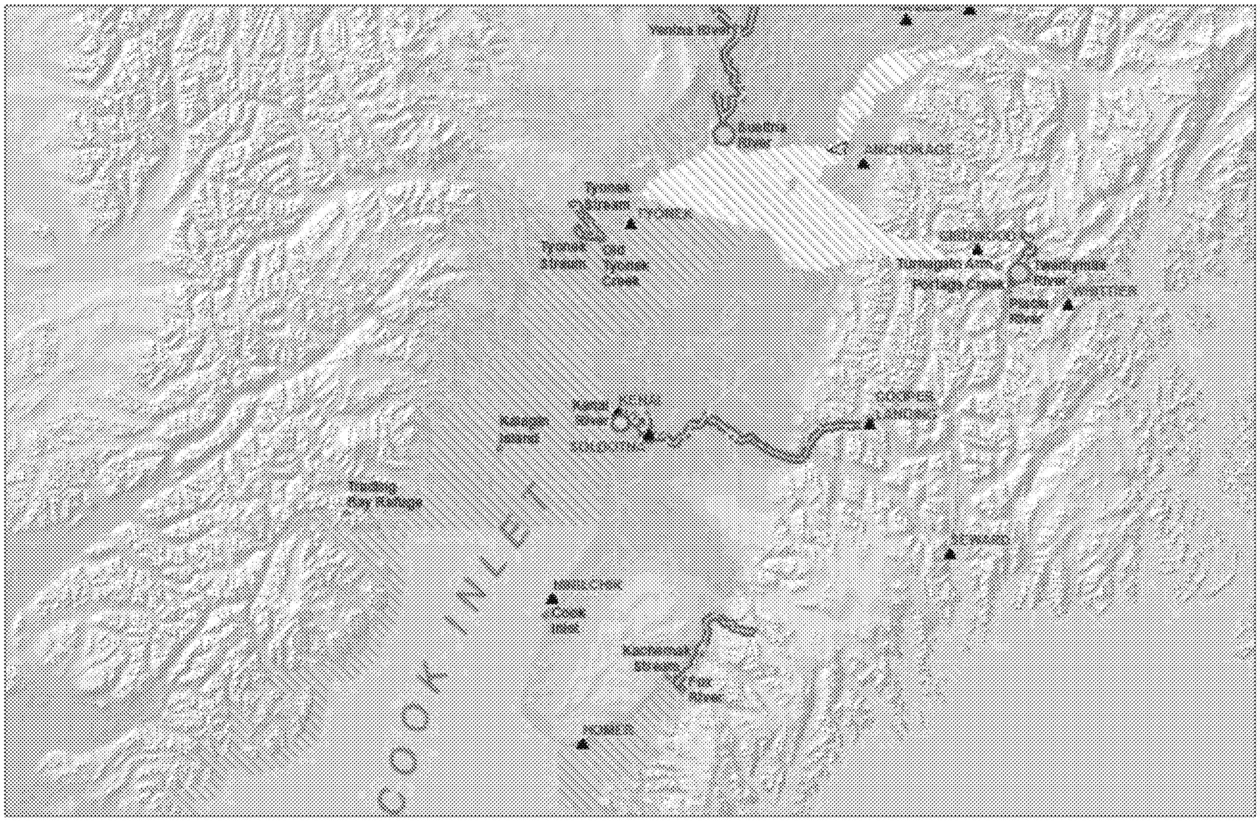

Figure 2.3.3 - Eulachon distribution in Cook Inlet rivers (Source: AEA 2013).

2.3.7.2 Longfin Smelt (*Spirinchus Thaleichthys*)

It was noted by Houghton (2005a) that the longfin smelt would be a likely prey species consumed by belugas during months of September and October in the Cook Inlet (see Table 2.3.2). Although longfin smelt have not been identified in stomach contents, it is a possibility that these are part of the Cook Inlet beluga diet and are thus included in this review. Note that longfin smelts are much smaller than eulachon.

Longfin smelt are mostly anadromous species although landlocked populations are known (Morrow 1980). Longfin smelt can be distinguished from other smelts by their long pectoral fins. They typically measures 10-14 cm standard length, although third-year females may grow to almost 15 mm. The known range of the longfin smelt extends from the San Francisco Bay-Delta in California northward to the Cook Inlet in Alaska. In Alaska, the range is Shelikof Strait, southwestern Gulf of Alaska including Cook Inlet and Prince William Sound, south along coast through Southeast Alaska (Mecklenburg et al. 2002, Shields 2005). They are moderately widespread in south coastal and southeastern Alaska and are considered locally and seasonally abundant, appearing chiefly during spawning runs (Morrow 1980). Large numbers are apparently found in the Gulf of Alaska 5 to 6 miles offshore (USFWS 1994).

Most longfin smelt migrate up coastal rivers to spawn in freshwater and then move downstream to brackish water to rear. The life cycle of most longfin smelt generally requires estuarine conditions. They usually live for 2 years, spawn, and then die, although some individuals may spawn as 1- or 3-year-old fish before dying. Adults spawn at age 2 in streams not far from the sea. In British Columbia and most of range, spawning occurs October-December (Morrow 1980). In the Cook Inlet, longfin smelt return in the fall (Shields and Dupuis 2013). Females lay 5,000-24,000 adhesive eggs that hatch in about 40 days (Lee et al. 1980). Juveniles remain in freshwater for approximately one year before moving downstream to marine habitats or lacustrine habitat for landlocked populations.

Longfin smelt were fairly abundant in Knik Arm and comprised 13.6 and 22.5% of the total beach seine catch (Houghton et al. 2005a, b). However, longfin smelt comprised only 1.8% of the total tow net catch in Upper Cook Inlet (Moulton 1997).) Few longfin smelt were collected during trawl sampling near Chisik Island in August 1997 and May 1998, but longfin smelt comprised 15% of the total catch in August 1998 (Fechhelm et al. 1999).

2.3.8 Summary of Cook Inlet Beluga Fish Prey Species

Table 2.3.4 summarizes the fish species that are the most likely to comprise the Cook Inlet beluga diet and considered preferred prey based on information reviewed. Depending on season, salmon and eulachon are highly to moderately abundant. Saffron cod are common except in mid-winter in Upper Cook Inlet. Pollock and yellowfin sole are rare in Knik Arm. Pacific cod are found in central Cook Inlet but are not documented in Knik Arm.

Salmon and eulachon are dominant in beluga diets during spring and summer as they are relatively abundant during spawning runs.

Outmigrating salmon smolts are abundant in some estuarine habitats and would be consumed by belugas.

Due to high turbidity in the Cook Inlet, it is thought that schooling behavior may not be stimulated and that some prey species may be more dispersed. Thus, more difficult to consume in abundance.

Other fish prey species that are relatively abundant in the Cook Inlet are not present in high concentrations. These include benthic species such a Pacific cod and flounder species, and pelagic species such as walleye pollock.

Longfin smelt are relatively abundance at some river mouths during fall spawning. However, these fish are very small.

Other marine species that do not have schooling behavior and are relatively small-sized and perhaps lower in abundance, such as sculpins and sticklebacks, are probably consumed opportunistically by belugas.

Finally, belugas feed opportunistically on freshwater species that may be encountered such as suckers, whitefish, and trout.

So only a few species will be consumed consistently –migratory species that occur in some areas in high abundance seasonally – salmon and eulachon.

Some marine species that have relatively higher abundance (but do not occur in abundance seasonally) are more common in the diet particularly in the non-spring summer period (cod, flounder, and pollock).

Table 2.3.4 - Summary of Cook Inlet beluga whale diet/prey preference.

Species	Importance in Beluga diet	General Season of availability	Comment
		Pelagic species	
Salmon species			
Chinook Salmon	Primary	Spring-summer	Seasonally abundant in Upper C.I.
Chum Salmon	Primary	Spring-summer	
Coho Salmon	Primary	Spring-summer	Seasonally abundant in Upper C.I.
Sockeye Salmon	Primary	Spring-summer	
Pink Salmon	secondary	Spring-summer	Limited to a few systems
Other pelagic species			
Walleye Pollock	Primary	Fall-spring	Low abundance in Upper C.I.
Pacific Eulachon	Primary	Spring	Seasonal abundance in several systems
Longfin smelt	secondary	Fall	Abundant in Upper C.I. not documented in beluga stomachs
		Benthic species	
Cod species			
Pacific cod	Primary	Fall-spring	
Saffron cod	Primary	Fall-spring	
Flounder species			
Yellowfin sole	Primary	Fall-spring	Common in lower C.I. not reported in Upper C.I. or Knik Arm

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2.4 Hydrodynamics of Cook Inlet

2.4.1 Bathymetry, physical features and seasonal dynamics

The Cook Inlet is a long, narrow, subarctic estuary, which extends more than 350 km up to Anchorage and ends in two narrow extensions, the Knik Arm north of Anchorage, and the Turnagain Arm, southeast of Anchorage. It is a large semi-enclosed basin of 83km average width (maximum width ~150 km), and several constrictions (of up to 16km between the East and West Forelands in Central Cook Inlet) within the basin. The bathymetry of the Cook Inlet is extremely complex, with deep basins along the mid-line and steep and abrupt shoals interspersed with deep pockets, and depths ranging from 175 meters to mudflat areas (Figure 2.4.1a-b; M. Zimmerman and M.M. Prescott, 2014; figures are presented at the end of section 2.4). Multiple types of physical forcing, and in particular the large tidal range, which is one of the largest tidal ranges in the world, drive the prevailing circulation patterns which vary in direction and magnitude over the tidal and seasonal cycles and include rip current features (Figure 2.4.2a-d). In general, circulation is counterclockwise, with the fresher, turbid water from the northern Cook Inlet flowing out along the western coast (hugging the western shoreline due to the Coriolis effect), with intrusion of clear oceanic waters along the eastern coast. At Kalgin Island, complex patterns emerge due to a front formed by converging flood and ebb tides, along with steep shoaling. Along with these general patterns forced primarily by tidal action and river discharge, surface currents can vary, depending on the morphometry, bathymetry, and prevailing winds, which can be northerly or southerly.

Much of what is known about the physical dynamics in Cook Inlet was first described by Burbank (1977), Muench (1978), and Muench et al. (1981) and include descriptions of the major unique features of the Cook Inlet physical oceanography, including multiple riptides that follow the deep channels and bathymetric contours of the basin. However, much of the data relate to the spring and summer condition (some winter measurements in Muench et al 1981), and little is known about currents in autumn through winter. More recently, simulations of tidal and riverine flow (Ezer et al. 2009; Oey et al. 2007) using the Princeton Ocean Model, and lagrangian transport simulations using FVCOM (Cheng, 2010) have borne out many of these initial observations by Burbank and additionally quantified the scale of wetting and drying and transit time at the surface, respectively, again for the ice-free conditions.

Further, the Oey et al. 2007 simulations included sensitivity tests with windstress in addition to tidal and baroclinic forcing, and windstress (despite strong prevailing winds along the length of Cook Inlet, from the north in the winter and south in the summer) does not influence the large scale hydrodynamics significantly, which are mainly driven by tidal and baroclinic forcing. Oil spill tracking has provided comparable information about surface currents. Oil released near Nikiski dock north of Kenai on the east side of the inlet from a grounded ship, instead of traveling northward as would be expected due to constant southwesterly prevailing winds, crossed to the west side of the inlet and oiled beaches to the west of Kalgin Island, a southwesterly trajectory, within four days of the initial release (Johnson and Okkonen 2000). In contrast, in winter with prevailing northerly winds, an oil spill followed the prevailing winds and traveled toward the south and reached the rip tide, and as the wind reinforced the trajectory, the oil spill remained within the rip current. Further, winter observations have shown a predominant surface movement from the southern tidal intrusion to the west side of Kalgin Island and then back east across the inlet as the saline water travels north, while water from the north moves south along the rip current. As this occurs, gyres form off of the north end of Kalgin Island, and is particularly strong during fall and winter. This can be seen in buoy trajectories (Figure 2.4.3) whereby buoys released to the east of Trading Bay in the central rip current spent 5 days circling Trading Bay prior to reaching the Forelands to the south, and the next month traveling around Kalgin Island.

Within the Cook Inlet the prevailing tides are semidiurnal, and the tidal scale is similar to the lengthscale, and thus tidal amplification occurs, which varies depending upon location but increases northward and can be up to +-5 meters at the north end of the Inlet (Oey et al., 2007). In contrast to the 1-2 m tidal range found in the Gulf of Alaska, northern Cook Inlet tidal range is 8-10m (Ezer et al. 2013), with spring tides up to +12m at the very north end of the Inlet. The Turnagain and Knik arms in northernmost Cook Inlet expose large mudflats during low tide, which are inundated at flood tide, as demonstrated in model predictions of typical conditions and in remote sensing imagery, revealing up to 500 km^2 of mudflats exposed twice daily (Ezer and Liu 2009; Ezer and Liu 2010; Ezer et al. 2013). The mudflats are expansive enough to be viewed from space using satellite technology (Ezer et al. 2008; Ezer and Liu 2009). Tidal currents in the upper inlet are strong, leading to tidal bores of up to 5 m/s on flood tide due to the narrowness and abrupt shoaling of the Turnagain Arm (Ezer et al. 2013; Ezer and Liu 2010; Ezer et al., 2008). The mudflats are inaccessible by boat and combined with strong currents renders it a difficult area to monitor, and therefore, measurements are sparse (Ezer et al. 2008).

Freshwater flow into Cook Inlet influences the physical dynamics, and freshwater forcing is particularly strong during the spring ice melt, followed by rains through early summer and relatively dry conditions after September (Okkonen 2005). There is a strong north-south salinity gradient, which together with tidal forcing drives the prevailing circulation. There are several types of ice that affect Cook Inlet – sea ice, pack ice, estuarine/river ice, and shorefast ice that can be restacked with tidal flood and ebb. Sea ice tends to form in October and November and melts in March and April. Spring and summer discharge of snow and glacial ice melt can be extremely large on the order of $5X10^{-3}$ m^3/s, and the complete tide-riverine mixing time scale is about 3 months (Oey et al. 2007; see Figure 11 in Oey et al.).

Eleven major watersheds drain into the Cook Inlet. The largest river discharging into Cook Inlet is the Susitna River located at northern Cook Inlet, with a drainage area of 15,770 km^2, and July discharge of nearly 24,000 cfs (for all streams, maximal discharge is in May, moderately high and variable into the summer and decreasing and remaining low throughout fall/winter). Other rivers of interest in northern Cook Inlet include the Chakachatna-McArthur (drainage area 2867 km^2, July discharge 14,470 cfs), Chuitna, and the Beluga River, which empty into Trading Bay; the Little Susitna in northern Cook Inlet; the Matanuska (July discharge of 12,000 cfs) and Knik Rivers (July discharge of 24,000 cfs) on the Knik

Arm; and the Kenai and Kasilof Rivers on the eastern Cook Inlet (Gatto 1975, 1976). The Matanuska, Knik and Susitna Rivers contribute approximately 70% of the fresh water discharged annually into the inlet. The upper Cook Inlet is generally much more fresh in summer during the peak discharge period than in the winter.

The Cook Inlet is ringed by mountains and dominant winds are from north to south (Schumacher 2005 and references therein). The prevailing winds influence the timing and location of upwelling along the coast (Schumacher 2005). Rough weather and high windstress influence the surface throughout the year but particularly in winter; at this time, winter ice, shifting channels during the spring, large currents (up 4-5 m/s), and large tidal range and tidal bores are all features that influence circulation in the inlet (Zimmerman and Prescott 2014). Satellite mapping and fishers' observations have confirmed that rip tides can be produced throughout the basin, in areas with steep bathymetric contours, such as at the Kalgin Island shoals (Oey et al., 2007). The topography and bathmetry of Cook Inlet lead to complex circulation, with topographically induced gyres located along the length of the inlet, and rip tides that occur due to the steep bathymetry with abrupt shoaling points. Rip currents were first quantitatively described based upon drogue drifter trajectories in Burbank et al. 1977 for the southern and mid Cook Inlet. It was observed that the rip currents formed along steeply changing topography along the midline north to south within the basin, with east and west rip currents (see Figures 2.4.6 and 2.4.7). During flood tide, debris gathers in a convergence zone, while during ebb tide, the debris field broadens out. Within the 3km convergence zone currents are very turbulent and boils are produced, along with large waves. The sound of the convergence can be heard 500 m away, and large logs can be pulled under in the swift currents (Burbank et al. 1977). Additionally, persistent winds have been found to enhance subsurface currents (Burbank et al. 1977).

Mixing pools can form along the length of the inlet, including near the end of Kalgin Island and near the mouth of Kachemak Bay, with collections of algae, zooplankton, and detritus as identified by local tribal members during interviews (USEPA 2006), and the pools have been found to attract marine birds and wildlife (Schumacher 2005). In the northern Cook Inlet, large scale eddy formation is predicted only when freshwater enters the upper inlet from rivers, coupled with the tidal forcing (Ezer et al 2009). The eddy systems include a strong eddy system east of Point Woronzof, located near the Asplund wastewater treatment plant off of the city of Anchorage, and another gyre at Cairn Point. Other gyres can be seen at river mouths, including the Susitna River, where documented northerly coast-hugging currents and southerly offshore currents have been documented (Gatto 1975, 1976). Topographically-induced gyres are also predicted to form in the southern Cook Inlet (Figures 2.4.2c and d).

Residence times in several areas of Cook Inlet have been estimated using the tidal prism method (or modified tidal prism method; Gatto 1975). In March, the residence time for water in the Knik Arm was estimated to be 205.3 hours (205.6 hours modified). In July, the residence time is reduced, to 13.1 hours (13.2 hours modified); the annual average is estimated to be 47.9 hours (48.2 hours modified). Kachemak Bay residence times were estimated to be 773 hours (774.3 modified) in March, 17.07 in July (18.0 modified), and annual average 58.8 (59.3 modified). During the spring when stratification is weak, salinity and temperature data indicate that Kachemak Bay is restricted in its exchange with Cook Inlet, although as stratification increases in summer and at times of weak tidal mixing, exchange increases (Okkonen and Pegau 2009).

Although generally the Knik Arm is thought to impart high turbulent diffusion and rapid mixing due to the large tidal range, there is evidence that eddy formation in the bay to the east of Pt. Woronzof could serve to trap pollutants near the ocean outfall of the Anchorage sewage treatment plant (Gatto 1975, 1976). Detailed measurements have shown that a clockwise eddy forms to the east of Pt. Woronzof during flood tide, and a counterclockwise eddy forms on the southwest side during an ebb tide (Gatto 1975, 1976). Although it is difficult to estimate residence times in the gyres within Cook Inlet, it has been observed that southern Cook Inlet gyres outside of Kachemak Bay entrained surface drogues for on average one week and observed entrainment up to 15 days (Burbank et al. 1977). In addition, movement past the outfall is relatively rectilinear (to and fro) with little cross current. Which, although diffusing pollutants, could serve to retain a pollutant plume in the vicinity of the outfall. At Kenai, clear ocean water intrusion upriver at times can act to dilute pollutant concentrations at the Kenai River during flood tide (Gatto 1975, 1976).

Data from surface buoys deployed in the central inlet corroborate the differences in trajectory and residence time within the inlet, depending on location of deployment. Some buoys deployed quickly left stayed in the central inlet for 15 days, while others remained for 25 days in the inlet (Johnson and Okkonen 2000). The predicted effect of local rip currents on the central inlet oil and gas plumes would be to elongate the plumes in narrow ribbons. There can be some turbulent drawdown (pumping) temporarily submerging floating debris and plumes, depending upon the proximity to rip currents. The twenty-four oil spills from 1984-1999 were concentrated in Trading Bay and the north central Cook Inlet (Johnson and Okkonen 2000), with several near the major tanker docking facility near the Nikiski dock. Very little current information is available for the areas through the Forelands into Trading Bay.

Temperature, salinity, and turbidity vary from season to season and interannually. Temperatures range from over 15C in summer to below freezing in winter (average annual temperatures ranging from 10.5-13C, and the number of months per year below freezing ranges from over 3-5 months (based upon 1995-2009 data; Ezer et al. 2013). Western Cook Inlet water tends to be cooler than oceanic water intruding from the Gulf of Alaska in winter and warmer in summer (see e.g., Feely 1982; Pegau et al., 2005), and the Gulf of Alaska water intrudes further, faster, into the Cook Inlet during times of less freshwater flow. The upstream geology comprising glacial flour and eroded bedrock renders large contributions of sediment to glacially-fed streams, with concentrations upwards of 2,000 mg/L compared to non-glacial streams with sediment concentrations closer to 50 mg/L, and total load is upwards of 19 million tons of sediment, most of which is contributed in summer (Gatto 1975, 1976). Bottom scouring and suspension due to tidal currents was observed in satellite remotely sensed false true color data of the Kenai River plume, where rocks and bottom sediments are relatively shallow (Gatto 1975, 1976). Remotely sensed sediment plumes from the local rivers have detected remnants of plumes, showing entrapment of river sediments within the vicinity of a plume over multiple tidal cycles (Gatto 1975, 1976).

When upwelling favorable (northerly) winds occur, given the small Rossby radius of deformation of less than 10-20km at the latitude of Cook Inlet, it is likely that localized upwelling takes place along the eastern shore of Cook Inlet. This would contribute to highly productive waters to support the fisheries and predators, including beluga, in Cook Inlet. However, in places where turbidity remains high, in northern Cook Inlet (Figure 2.4.4) and during times of peak runoff, it has been found that primary productivity is reduced compared to clear waters despite ample nutrient availability (Speckman et al. 2005).

2.4.2 Cook Inlet Physical Environment: Implications for Beluga and Beluga Critical Habitat

Marine mammals in cook inlet must adapt to the large temperature ranges in the Upper Cook Inlet, from over 15C in summer to below freezing in winter, together with large swings in precipitation, riverine discharge, and tidal range which together result in large daily, seasonal, and interannual variability. Cook Inlet beluga must be able to avoid a variety of threats such as stranding on tidal mudflats, fast moving floating ice, tidal bores and attacks by predators that are found within beluga critical habitat (Figure 2.4.5). It has been hypothesized that because of the difficulty in regulating their movement over mudflats with quickly changing tidal heights, beluga have been found to strand more often after the highest peak of the spring tides (Ezer et al. 2013).

The location of Cook Inlet Beluga within the inlet varies seasonally, and the presence of beluga has been found to be statistically significantly correlated to river discharge, with the timing of seasonal beluga dynamics associated with variance in peak flow timing (Ezer et al. 2013). Beluga populations in the northern Cook Inlet follow the magnitude of discharge, favoring the Susitna when flow is high, and alternatively flows in the Knik and Turnagain Arms of the northern inlet, as flows change over the year and interannually, and are linked to predator dynamics. Beluga move seasonally, dispersing to points in central Cook Inlet south to Kalgin Island in winter, and in spring and summer, moving north, first to the Susitna River, and then later in fall to the Turnagain and Knik Arms of the Northern Cook Inlet. In addition, the geographic location of the Beluga from year to year in the Inlet depends upon temperature and ice dynamics, such that in warmer years, beluga are found in northern Cook Inlet for a longer period of time prior to dispersing to the central and south Inlet in winter.

On tidal time scales, beluga have been seen to take advantage of flood tides to swim more easily over the large mudflats in the northern Cook Inlet in order to reach northern river deltas (Ezer et al., 2008). Using a numerical hydrodynamic model, remotely sensed satellite data of mudflat extent, and beluga satellite telemetry information, the belugas in the Knik and Turnagain Arms were found to pass from deep waters that at low tide were blocked from shallower northern waters by sills, to shallow waters near river deltas upwards of 10-20 km away, within one tidal cycle. It was also found that the location of the beluga correlated strongly with sea level in the Turnagain and Knik Arms, with the slope of the correlation steeper for the Knik Arm than the Turnagain Arm. In the upper inlet, satellite telemetry studies have shown that beluga are found to move up the inlet at high tide and down the inlet at low tide (Ezer et al. 2008), on a scale of 30-50 km during the tidal cycle such that they are not trapped on mudflats during low tide. Due to nonlinear currents and tidal dynamics in Turnagain Arm, the beluga swim speed did not correlate with current speed, whereas in the Knik Arm where currents were more linear, beluga swim speed correlated strongly with current speed. It has been noted that since the configuration of the shoreline can affect the tidal flux, which in turn drives beluga and beluga prey behavior, it is important to have information about the impacts of human activities on the shoreline in order to predict how beluga will ultimately respond (Ezer et al. 2008). Beluga tend to dive in deeper waters in the middle inlet in December-May, due to a different foraging tactic to feed on demersal or pelagic fish species, whereas in spring through autumn, strong clustering in shallower waters is seen, when foraging depends on salmon (Goetz et al., 2012).

2.4.3 Site-specific Dynamics and Implications for Permitted Mixing Zones: Pt. Woronzof (vicinity of Asplund WWTP Outfall), Trading Bay, and Kenai Peninsula

Beluga critical habitat is located throughout the central and upper Cook Inlet, as well as along the coastal margins of Cook Inlet further to the south, and throughout Kachemak Bay. As the tidal range within central and upper Cook Inlet is large and variably impacts the coast and critical habitat, it is important to precisely characterize mixing zones that can affect critical habitat. The CORMIX model is a plume simulation model for predicting mixing zone areal extent, shape, and dilution properties that is commonly employed in the NPDES permitting context. CORMIX model simulations are steady state and deterministic, therefore, although conservative assumptions may be made for the steady state determinations, they may not be conservative over the dynamic range of the conditions at the site. The models include boundary information such as depth, current speed, current direction, salinity, temperature, and stratification to predict the amount of dilution when effluent is mixed with receiving waters. However, the existing data used for dilution modeling in upper Cook Inlet is sparse. In particular, salinity, temperature, stratification, and tidal current and direction data are sparse for the central and upper Cook Inlet, and improvements in data for tidal currents and stratification, including salinity and temperature data, could be utilized to determine more realistic mixing zone areal extent, shape, and dilution with distance estimates, and also be used to predict seasonal effects on the dilution of effluent (Pippin 2005, Proceedings of the Cook Inlet Physical Oceanography Workshop, 2005).

Pt Woronzof, Asplund Wastewater Treatment Plant and Port of Anchorage Terminal at Cairn Point

Currents at Pt. Woronzof, located at the southern margin of the Knik Arm in upper Cook Inlet, can reach 4 m/s on flood tide and 6 m/s on ebb tide, with currents of effectively zero at slack tide. Given the extreme tidal range at the upper end of the Inlet, the mid to upper Knik Arm displays significant wetting and drying and mudflat formation (Oey et al. 2007), and sediment loads are extremely large when discharge is high from the watershed. Pt. Woronzof is a known location of topographically induced eddy formation, and large topographic lows or "bowls" feature at low tide. The difference in tidal height between flood and ebb per the Oey et al. 2007 mean modeled condition is ~6-7m at the southern end of the Knik Arm. Just north of the point, persistent gyres form and act as areas of retention. The Knik Arm also features strong cross channel salinity gradients, similar to the central Cook Inlet.

A mixing zone verification study of the Asplund Pollution Control Facility (Wastewater Treatment Plant), located just to the northeast of Pt. Woronzof simulated the mixing zone of the current plant configuration (AquaTer 2013). The outfall comprises an 84-inch pipe with a trifurcated diffuser with 23 inch ports at 45-degree separation angles that extend 804 feet from Pt. Woronzof into the Cook Inlet. Each port is located 1-2 feet from the bottom of Cook Inlet. The plant is built for an average design flow of 58 mgd and design maximum of 154 mgd, with reported annual average discharge of 28 mgd. Given the expected density difference between the effluent and receiving water body, neutrally buoyant plume modeling was conducted using CORMIX model software. The assumed current speed was 0.2 m/s at low tide. In calculating the dispersion, a discharge field (mixing zone) of 1460m would be need to fully disperse the pollutants in order to meet water quality standards at the edge of the mixing zone. This mixing zone constitutes 399 water depths. In addition, because of the semi-diurnal tides and time of travel at that current speed, re-entrainment of the plume would occur, such that pollutant concentration near the outfall is likely. The above simulations were conducted with conservative "worst case" steady state assumptions (minimal tidal stage and lower 5th percentile of ebb flow velocity) but not necessarily conservative dynamical assumptions or worst case; the model effort was unable to capture reversing semidiurnal tides and expected pileup/re-entrainment because of such dynamics. The depth of the discharge ports ranges from 3.5-12.3 m, depending on tidal stage. The minimum depth of 3.5 m was used in the simulations as a conservative condition. The receiving water density was set to brackish density. The average daily discharge is 27.6 mgd, with maximum hourly discharge of 154 mgd, and summer effluent temperature of 16.0C, winter effluent temperature of 10.3C. For the summer condition, the receiving waters of Cook Inlet were specified as having a salinity of 4 parts per thousand (ppt) and a temperature of 15°C and for winter, a salinity of 21 ppt and a temperature of 2°C were specified. Simulations are necessarily unidirectional and do not reflect the local circulation patterns in receiving waters, such as the role of topographically induced gyres and entrainment, beyond current speed and general orientation compared to port angles.

The average dispersion with distance for the summer runs are calculated by AquaTER using the CORMIX Model assumptions for summer and winter:

Distance (m)	Total Dispersion (_:1) Summer	Total Dispersion (_:1) Winter
3.7	1.47	1.7
7.3	2.4	3.69
18.3	6.75	8.35
36.6	11.08	8.24
183	20.0	15.58

At 30 m from the discharge, the plumes lose jet momentum and begin to pile up and elongate downstream. With the 1460 m distance to dilute the effluent and reach water quality standards, over 2 hours would be needed, whereas tidal reverse would be initiated within 45 minutes. The assumptions in the AquaTER report highlight a modeling misconception compared to previous simulations (i.e., in CH2MHill's application of Visual Plumes to the same facility); that multi-port diffusers do not have additive dispersion, that rather re-entrainment amongst the port diffusers occurs and reduces the overall dispersion at one point in time.

Just upstream of the Asplund facility, at the Port of Anchorage terminal off of Cairn Point, significant deposition of fine sediment has been measured and attributed to flow divergence and slower flows near the Port (Hughes and Pizzo, 2003). Because of the topographic juts within the Knik Arm, including headlands such as Point MacKenzie, Point Woronzof, and Cairn Point, separation of the tidal flow occurs and gyres and formation of reduced flow areas with long residence times occur on the lee side of the headlands (Hughes and Pizzo 2003). These dynamics lead to complex currents along and across the Knik Arm and with depth. Further, the large source of sediment for deposition (i.e. the mudflats located just to the north of this section of the Knik Arm) provides and ample supply of particles to which pollutants can sorb and deposit. In dye tests of a three-dimensional table top model, dye injected at Cairn Point was entrained into the lee side south of the point (Hughes and Pizzo 2003). Because three-dimensional hydrodynamics contribute substantially to sediment deposition near the Port of Anchorage, it is critical to include three-dimensional modeling to better understand nearshore dynamics in this region, since depth-averaged models do not provide sufficient clarity in areas with steeply changing bathymetry and topographic shear (Hughes and Pizzo 2003).

Trading Bay

Although oil and gas facility produced water discharge in shallow coastal zones has been banned since 1997 due to the potential for widespread sediment contamination, Cook Inlet is exempted from the ban, with the rationale that deep water and swift currents would provide adequate dilution and render sediment contamination unlikely, and thus the Cook Inlet is treated like an offshore waterbody (Veil et al. 2004). Multiple oil and gas facilities and associated large mixing zones are located in Trading Bay. The Trading Bay is located at the terminal end of the Kalgin Island rip current (Johnson and Okkonen 2000), with rip currents continuing along the eastern edge of the bay. Rip currents form strong convergence zones where pollutants and debris can congregate. Strong currents occur through the East and West Forelands at the "pinch point" at the southern edge of trading bay, with currents at peak ebb reaching 6 knots (3 m/s) (Johnson and Okkonen 2000). Along with the eastern edge rip currents, strong convergence zone and gyres can be seen within Trading Bay in surface current summaries (Figures 2.4.3, 2.4.6 and 2.4.7).

Kenai

Kenai is located at the terminal end of one of the main rip currents along the baseline of Cook Inlet (main channel rip and east rip) (Johnson and Okkonen 2000) just to the west of the Kenai Peninsula. Rip currents form strong convergence zones where pollutants and debris can congregate. Oil spill trajectories are controlled more by tides and rip currents than by winds. Discharge in the summer runoff period is high and sourced from the Kenai River, to the northeast of the Kenai WWTP. CORMIX mixing zone analyses were conducted for the Kenai WWTP, with the following ambient current assumptions: 0.2 m/s, 0.6 m/s, 1.0 m/s, and 1.7 m/s to reflect changing currents over a tidal cycle. No information is provided on receiving water stratification, temperature, and salinity assumptions for the simulations. The Kenai WWTP rates a design flow of 1.3 mgd. The outfall is exposed for a couple of hours of the tidal cycle when lower minus tides occur (ADEC 2015). The permit issuance period is June 30, 2015 to February 1, 2020, and, in contrast to the previous 2008 permit, includes an acute mixing zone such that the acute criteria do not have to be met at the end of pipe. The chronic mixing zone authorized is a circle of 150 m radius and extends from the marine bottom to the surface (dilution of 18:1). The acute mixing zone is defined as a 7m radius circle, although at low tides, as mentioned above, the discharge is above the waterline for a couple of hours per day, thus ADEC estimated the dilution at half a circle of radius of 7m (chronic of half of a circle of 150 m radius) and dilution within the acute mixing zone of 6.7:1. Through the CORMIX modeling, ADEC estimated based on the higher tidal velocities that free-floating organisms would be exposed to the acute mixing zone for no longer than one minute.

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Figures for Section 2.4

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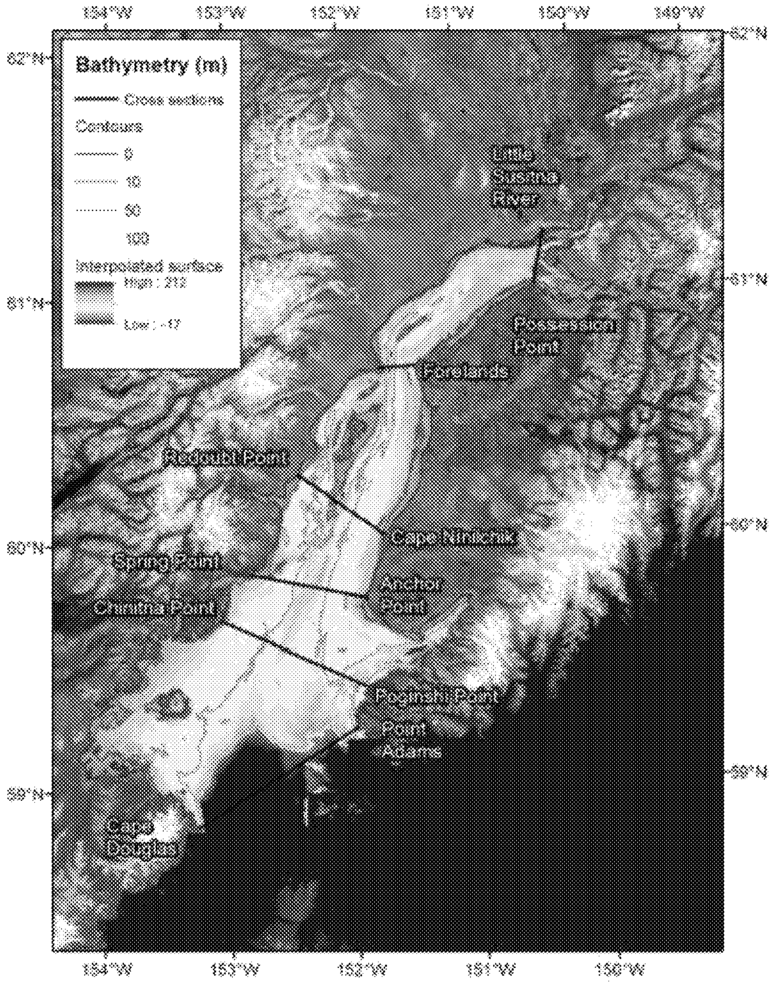

Figure 5. -- Bathymetry of Cook Inlet, Alaska, with an interpolated depth surface (50 m grid) and selected depth contour intervals. Straight black lines spanning the Inlet are six locations where horizontal areas or cross-sections of the water column were calculated. These data are not to be used for navigation.

Figure 2.4.1a - Bathymetry of Cook Inlet. Courtesy M. Zimmerman and M.M. Prescott 2014: NOAA NOS 2014 - http://www.afsc.noaa.gov/Publications/AFSC-TM/NOAA-TM-AFSC-275.pdf

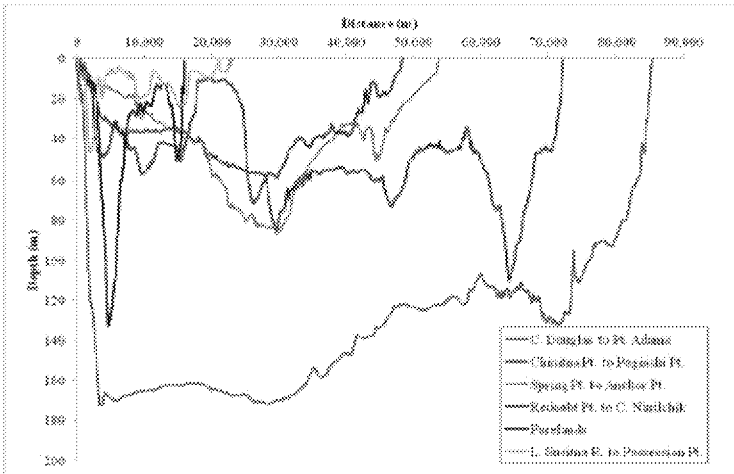

Figure 6. -- The horizontal profile, or cross-section, of the MLLW water column, as measured at six locations (see Fig. 5) ranging from the south end to the north end in Cook Inlet. The blue line shows a total horizontal area of 228,000 km^2 across the 85 km entrance to the Inlet, ranging from Cape Douglas on the left to Point Adams on the right. The next horizontal profile, shown in red, ranges from Chinitna Point to Poginshi Point, is nearly as far across as at the entrance, but only has one-third of the horizontal area. The next three lines - Spring Point (green), Redoubt Point (purple), and the Forelands (black) - have only one-fifth, one-seventh, and one-twentieth, respectively, of the horizontal area at the entrance. The northernmost horizontal profile, at the Little Susitna River, is only one-fiftieth of that at the entrance.

Figure 2.4.1b-Selected transects of Cook Inlet bathymetry as shown in Figure 2.4.2a. Courtesy NOAA NOS 2014 - http://www.afsc.noaa.gov/Publications/AFSC-TM/NOAA-TM-AFSC-275.pdf

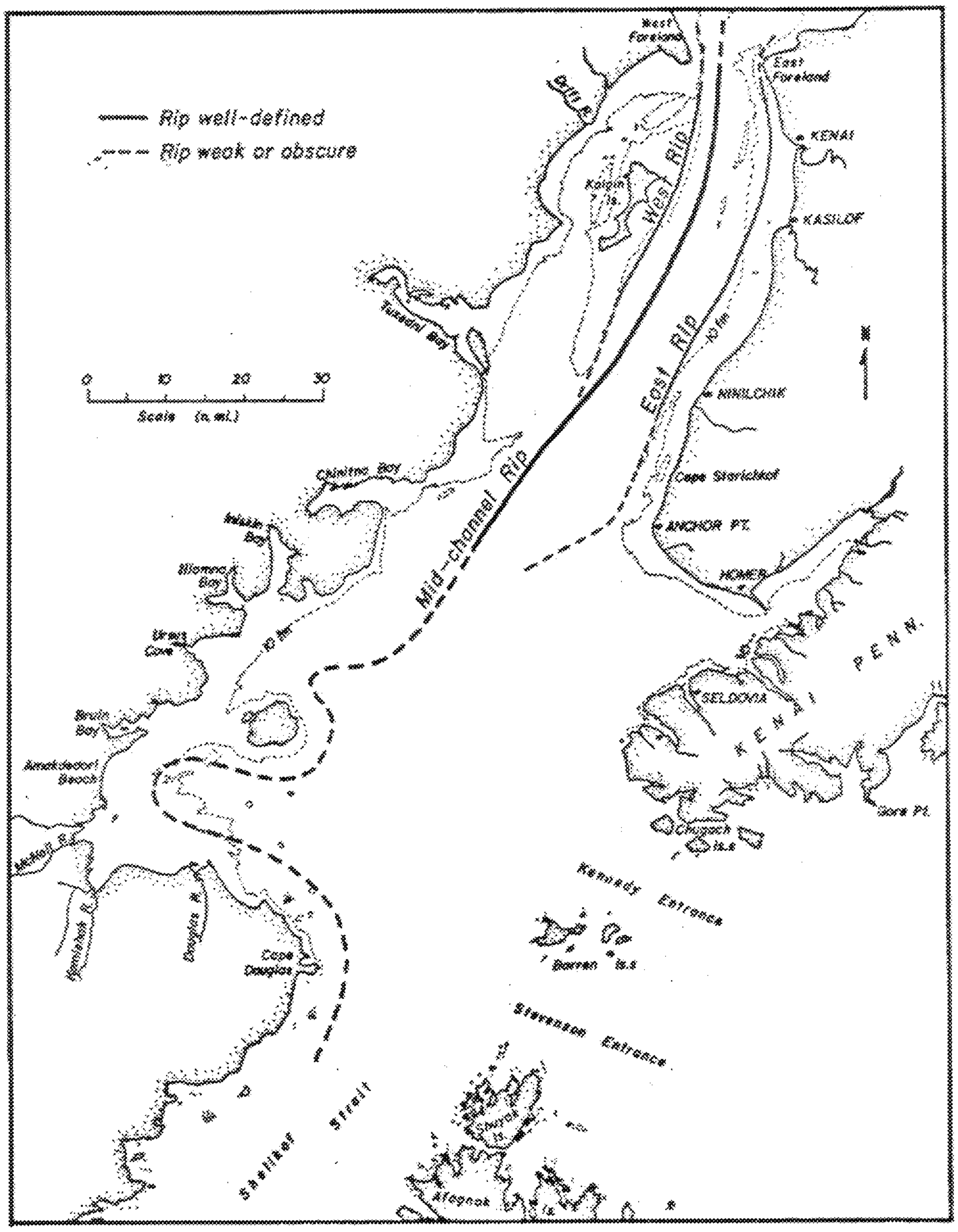

Figure 2.4.2a - Rip Currents in Cook Inlet. Excerpted from Johnson and Okkonen 2000 after Burbank 1974; 1977.

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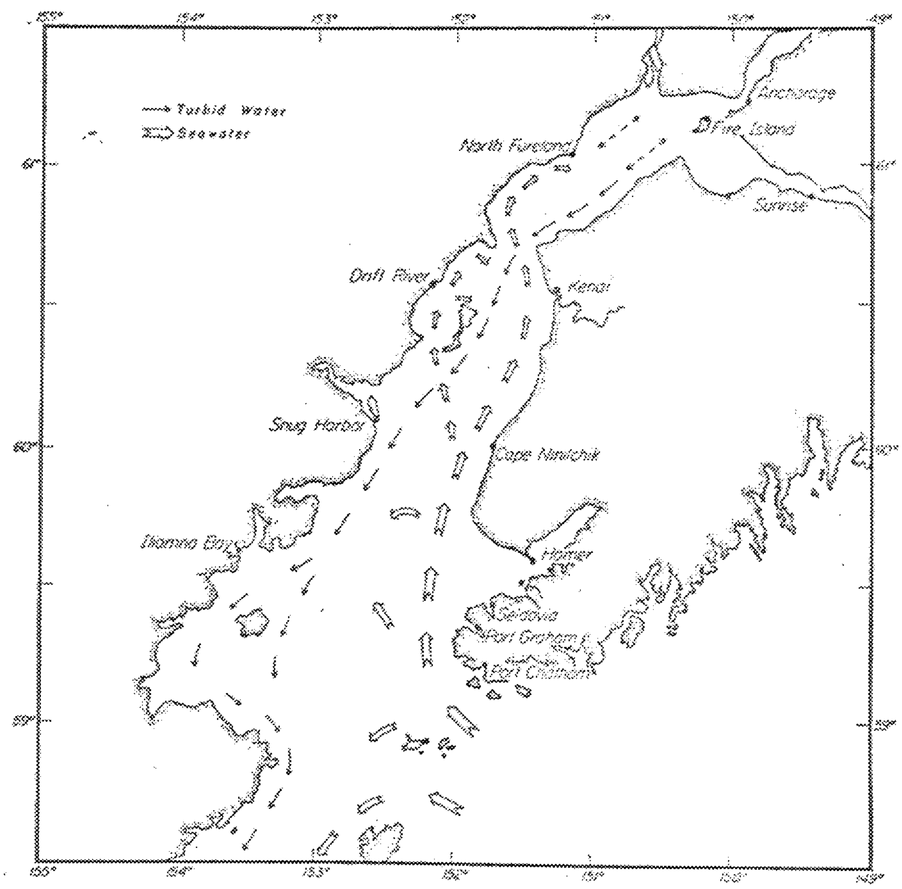

Figure 96. Net surface circulation within Cook Inlet inferred from from previous studies (after Burbank, 1974).

Figure 2.4.2b - Net Surface Circulation in Cook Inlet. Excerpted from Johnson and Okkonen 2000after Burbank 1974.

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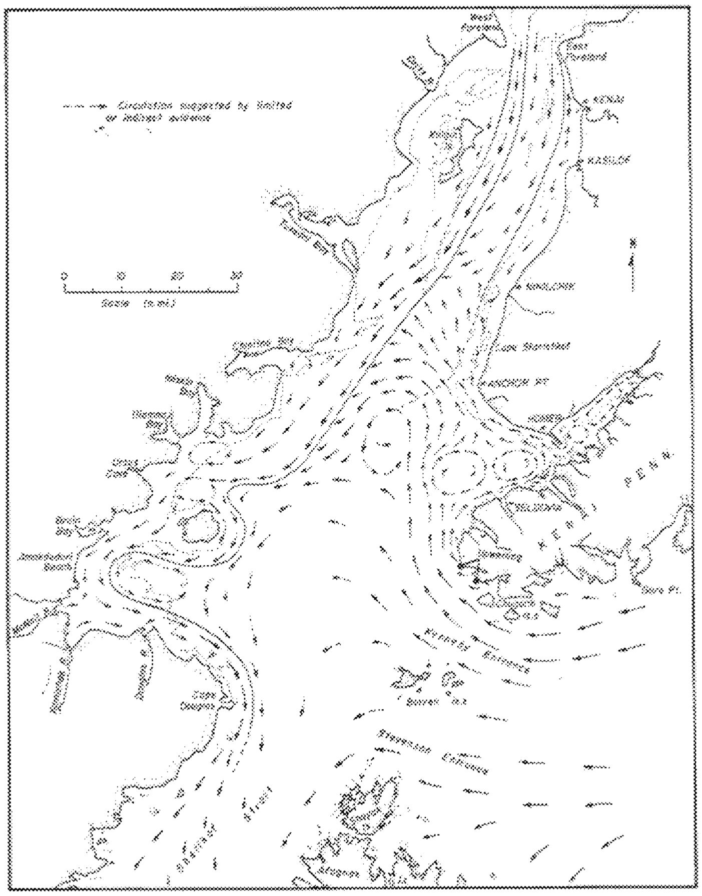

Figure 97. Net surface circulation in Lower Cook Inlet, based primarily on data collected during the spring and summer seasons.

Figure 2.4.2c - Net Surface Circulation in Lower Cook Inlet showing gyre formation. Excerpted from Johnson and Okkonen 2000after Burbank 1974, Burbank 1978, and Muench 1978.

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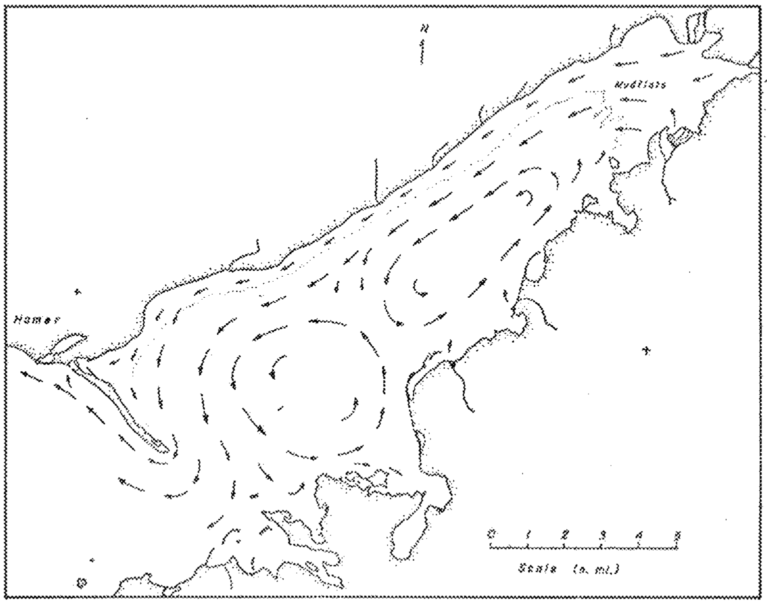

Figure 94. Surface currents in inner Kachemak Bay.

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Figure 2.4.2d - Net Surface Circulation in Kachemak Bay showing gyre formation. Excerpted from Johnson and Okkonen 2000after Burbank 1974, Burbank 1978, and Muench 1978.

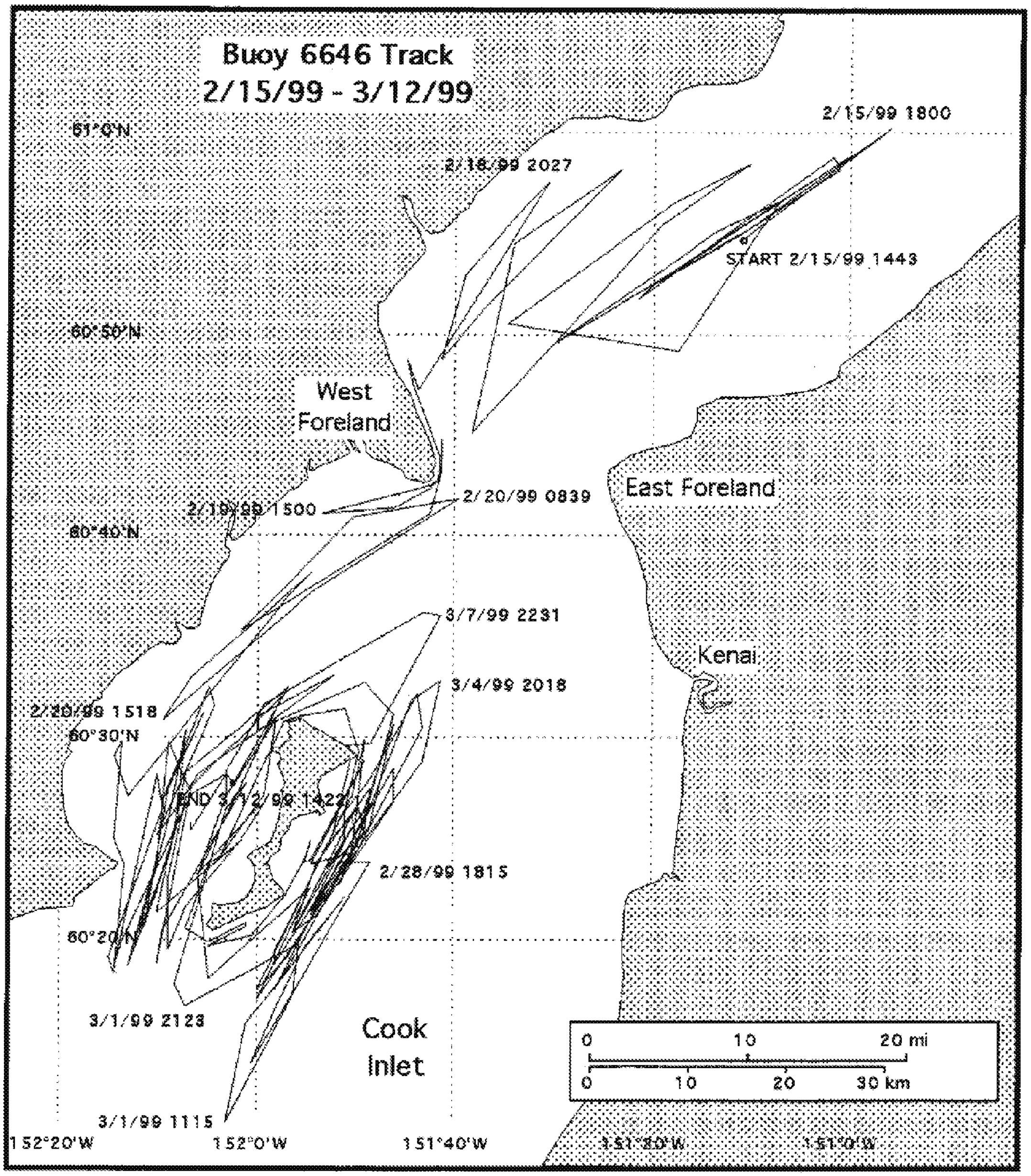

Figure 29. Buoy 6646 track, 15 February 1999 to 12 March 1999.

Figure 2.4.3 - Middle Cook buoy tracks showing retention in Trading Bay and near Kalgin Island. Excerpted from OCFO MMS- 2000-043

Figure 2. MODIS true color image of Cook Inlet acquired 2 September 2002.

Figure 2.4.4 - MODIS true color image of the Cook Inlet, showing major water clarity features and turbidity increasing to the north of the inlet. Excerpted from Okkonen, 2005.

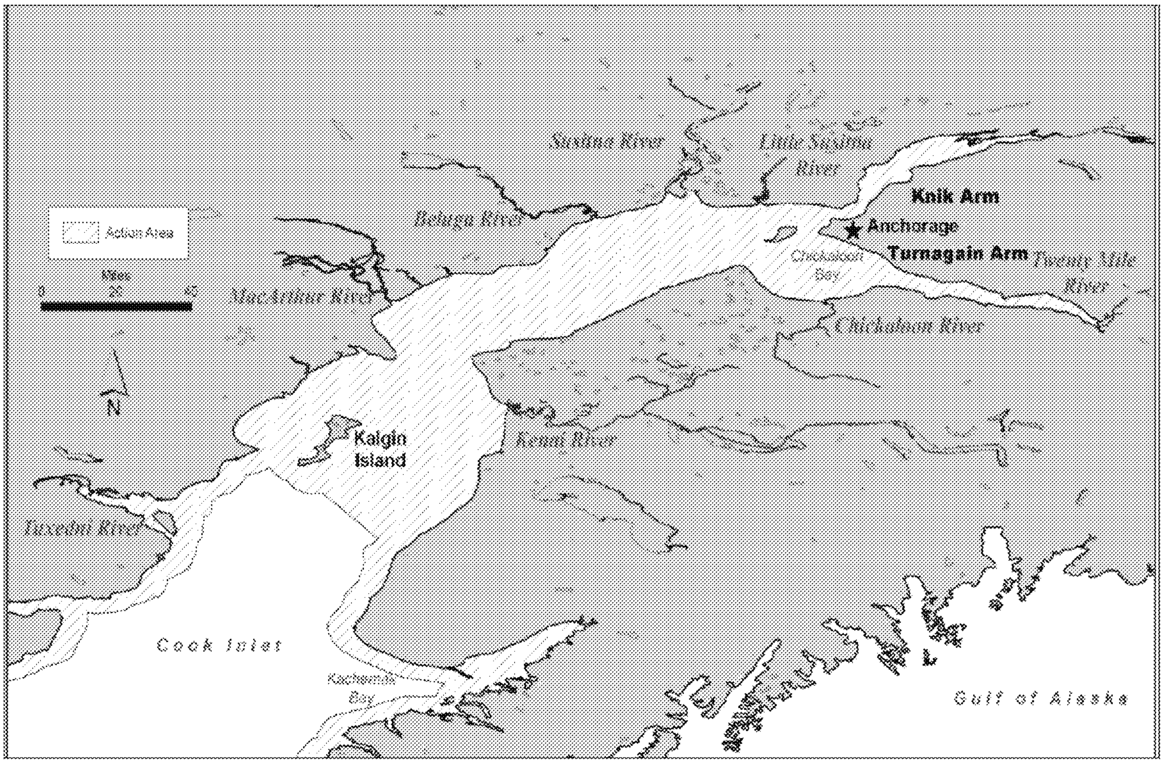

Figure 2.4.5 - Action area (from NOAA Biological Opinion, 2010)

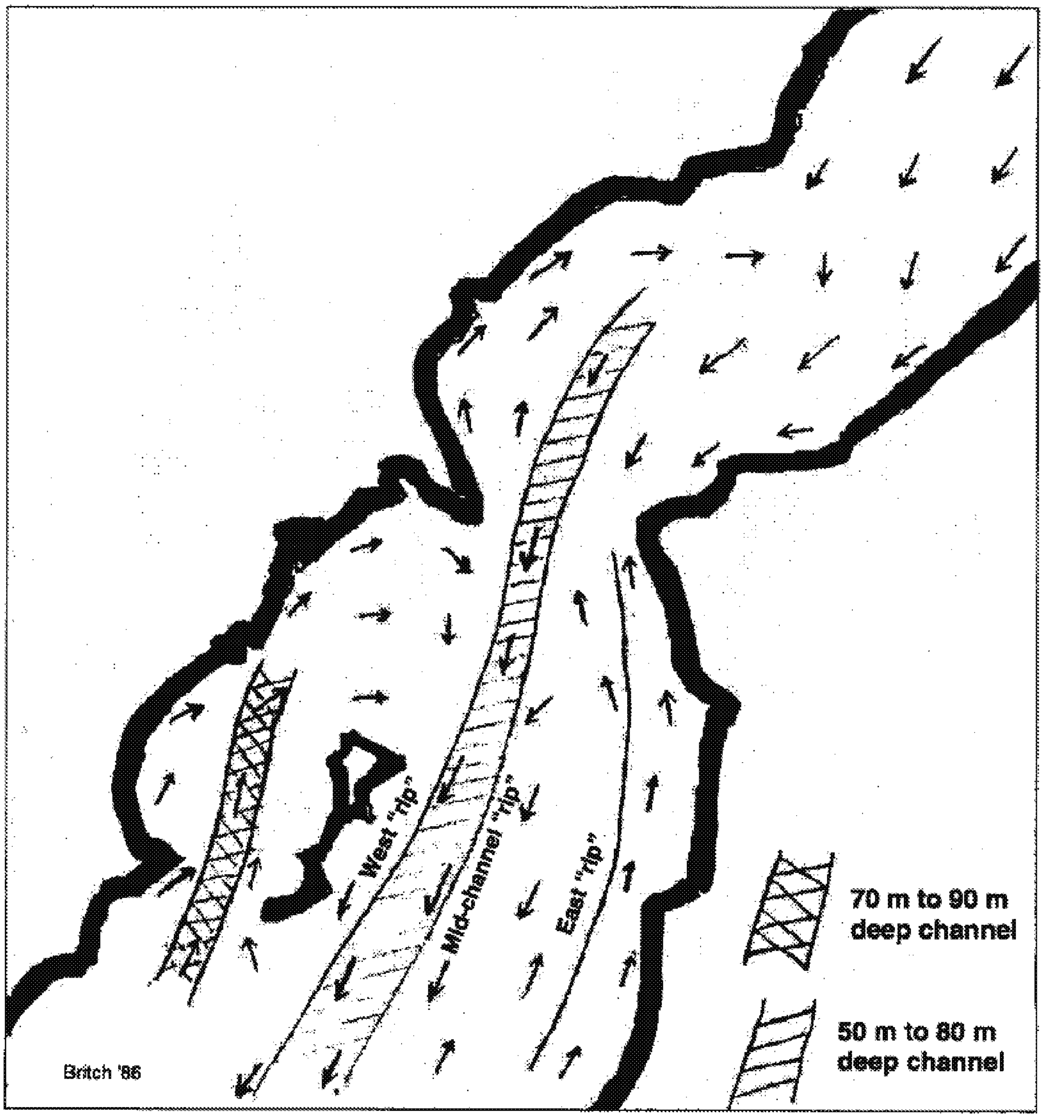

Figure 8. Middle Cook Inlet circulation and convergence zones.

Figure 2.4.6 - Middle Cook Inlet circulation and convergence zones. Excerpted from OCFO MMS- 2000-043

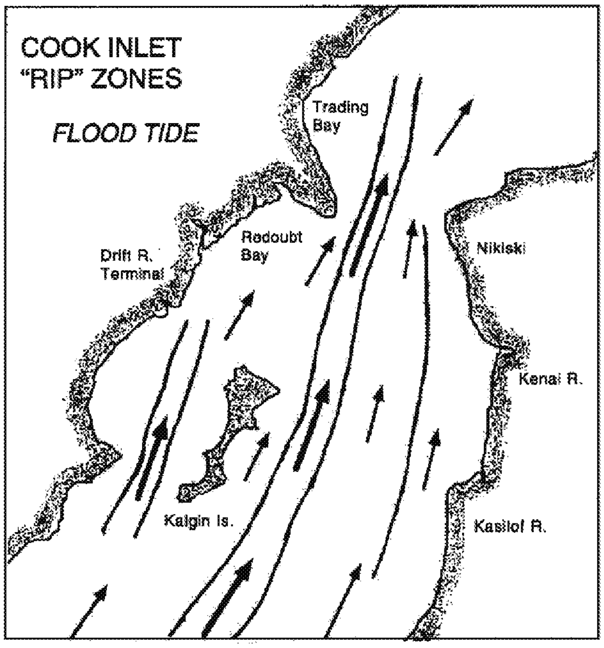

Figure 9. Cook Inlet "rip" zones – flood tide.

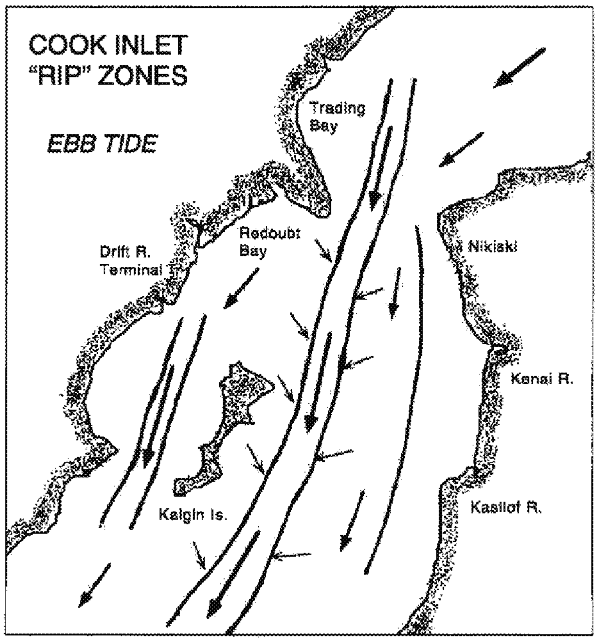

Figure 10. Cook Inlet "rip" zones – ebb tide.

Figure 2.4.7 - Middle Cook Inlet rip tides associated with flood (top) and ebb (bottom) tides. Excerpted from OCFO MMS- 2000-043

3.0 Effects of the Action on the PBFs of Critical Habitat

3.1 Approach to the Effects Analysis

Mixing zones are areas where certain water quality criteria are allowed to be exceeded, and Alaska's mixing zone rule establishes ADEC's authority to authorize mixing zones. The revised rule does not, however, propose or authorize any particular mixing zones. Nor does the rule specify the number, location, timing, frequency, and magnitude of mixing zones that may be considered for authorization. Rather Alaska's revised mixing zone rule contains provisions that are the basis for determining if and to what extent mixing zones may be authorized and for conditioning mixing zones to prevent or minimize their impacts. Consistent with this, EPA's action is on the substance of Alaska's revised mixing zone rule itself, not the proposed authorization of actual mixing zones or the past authorization of mixing zones under Alaska's rule prior to revision. EPA's analysis for this addendum to its biological evaluation is therefore focused on whether Alaska's revised mixing zone rule contains adequate provisions, which if implemented consistent with their wording, would prevent or minimize adverse effects to the Cook Inlet beluga whale's designated critical habitat by adequately limiting areas where water quality criteria are allowed to be exceeded within that habitat.

EPA conducted its analysis of Alaska's revised mixing zone rule by first identifying potential stressors or adverse effects that could occur as a result of exceeding water quality criteria within a mixing zone (e.g., acute and chronic water column toxicity and bioaccumulation). EPA then identified the PBFs of Cook Inlet beluga whale critical habitat that could be affected by a particular stressor or adverse effect, if mixing zones are not restricted and/or conditioned to prevent or minimize the adverse effect (e.g., PBF 2/Cook Inlet beluga whale primary prey species could be affected by pollutant concentrations that result in acute or chronic water column toxicity). Lastly, EPA identified the provisions in Alaska's revised mixing zone rule that are targeted towards avoiding or minimizing the impacts from the identified stressors or potential adverse effects (e.g., for acute water column toxicity, which could impact Cook Inlet Beluga whale primary prey species, are there provisions in Alaska's revised mixing zone rule that prevent or minimize acute water column toxicity?). Herein, EPA refers to this "programmatic" approach as its primary effects analysis.

Notwithstanding that this is a consultation on EPA's proposed approval of a revised rule, and not implementation of the rule, EPA believes that there can be uncertainty when implementing the mixing zone rule, particularly in a complex hydrodynamic environment such as that of Cook Inlet. This uncertainty can be particularly important when considering effects to critical resource areas such as a listed species designated critical habitat. Therefore, as a supplemental analysis to further inform the extent to which mixing zones may impact Cook Inlet beluga whale critical habitat, EPA also evaluated select existing mixing zones where the available information and data were sufficient to consider potential impacts to the PBFs. Herein, EPA refers to this as its supplemental effects analysis. Although the existing mixing zones were authorized under the version of Alaska's mixing zone rule which existed prior to the 2006 revisions, and do not necessarily reflect implementation of the revised rule, EPA believes the analysis can still be informative for purposes of this consultation. Despite the substantial revisions in 2006, the fundamental concepts of the two mixing zone rules are similar, particularly for waters of the type designated as Cook Inlet beluga whale critical habitat.

EPA's use of existing mixing zones for the purpose of illustration in the supplemental effects analysis was done without judgement of whether those mixing zones are fully consistent with Alaska's current mixing zone rule (prior to revision) and without judgement of whether those existing mixing zones would be fully consistent with Alaska's revised mixing zone rule. Furthermore, the extent to which permittees may at times be in violation of the terms of their discharge permits such that water quality criteria may be exceeded beyond the edge of a regulatory mixing zone, the potential effects of such violations, and the potential effects of other discharge permit violations or violations of Alaska's mixing zone regulation are beyond the scope of this consultation and were not considered.

The supplemental analysis is limited to a small subset of discharges to Cook Inlet beluga whale critical habitat for which mixing zones have been authorized under a NPDES permit, and is further limited to a small subset of pollutants that may be discharged into mixing zones at concentrations exceeding water quality criteria. A main point of the analysis is to illustrate how pollutant concentrations within mixing zones may exceed water quality criteria and thus may exceed effects concentrations for aquatic species that may be exposed to certain pollutants within mixing zones. Like analyses for other pollutants and other mixing zones would differ in details, but the main point would be the same. Therefore, because EPA's action is on the substance of Alaska's revised mixing zone rule, rather than the proposed authorization of actual mixing zones or the past authorization of mixing zones, EPA believes the level of detail in its supplemental analysis is adequate to complement the primary analysis and inform conclusions with regard to the potential effects of EPA's action on Cook Inlet beluga whale critical habitat.

With the exception of those criteria specified in Alaska's MZ regulation to protect the in-zone water quality of MZs (18 AAC 70.240(d)), it is not the purpose of this consultation to analyze whether meeting applicable water quality criteria is adequate to prevent or minimize adverse effects to Cook Inlet Beluga whale critical habitat. Therefore, no such analysis was performed by EPA. For both its primary and supplemental effects analyses, EPA also assumed that water quality criteria would be met at the edge of a mixing zone consistent with 18 AAC 70.240(c)(4)(A), "the mixing zone will not result in an acute or chronic toxic effect in the water column, sediments, or biota outside the boundaries of the mixing zone." The preceding are consistent with assumptions made by NMFS in its December 20, 2010, Biological Opinion for the Cook Inlet beluga whales themselves:

> *The protection afforded by WQS. For the purposes of this consultation, it is assumed that contaminant concentrations of Alaska's WQS, both acute and chronic, are sufficient in protecting aquatic life.*
>
> *Whether concentrations of contaminants meet the acute WQS at the edge of the ZID and chronic WQS at the edge of the mixing zones. The presumption with mixing zones in Cook Inlet is that dilution inside the perimeter of the mixing zone will allow for quick and even mixing to meet WQS and that contaminant concentrations outside the mixing zone will be reduced to levels that will not acutely or chronically affect aquatic life. For the purpose of this consultation, it is assumed that WQS are met at each EPA specified location in the mixing zone.*

For the primary effects analysis, EPA evaluated the potential effects on PBFs 1 thru 4. EPA's supplemental effects analysis was limited to PBFs 1 thru 3. PBF 4 was considered for the primary effects analysis because conceptually it is possible for mixing zones to affect the movement of aquatic organisms through or within a waterbody, and Alaska's revised mixing zone rule contains a provision explicitly targeted at addressing such potential effects. EPA did not, however, consider PBF 4 in the supplemental analysis because upon conversation with NMFS it was determined that effects to PCE 4 are not a concern in this case (Conference call to discuss draft BE addendum, NMFS and EPA, July 14, 2016). PBF 5 pertains to noise levels resulting in the abandonment of critical habitat areas by the whale. EPA does not anticipate that approval of the mixing zone rule or the discharges with mixing zones will result in elevated underwater sound. Therefore, PBF 5 is not evaluated in this BE addendum. The PBFs essential to the conservation of the Cook Inlet beluga whale are listed earlier in the introduction section.

3.2 Primary Effects Analysis

For PBFs 1 through 4, EPA's primary effects analysis considered possible effects of water quality exceeding water quality criteria within a mixing zone. Table 3.2.1 contains a summary of the potential adverse effects that could occur as a result of exceeding water quality criteria within a mixing zone, the PBFs potentially affected, and the provisions of Alaska's revised mixing zone policy that address the identified effects. A discussion of the Table 3.2.1 contents then follows, ordered by the potential effects as listed in the table (for the purpose of discussion, acute water column toxicity and acute sediment toxicity are combined, as are chronic water column toxicity and chronic sediment toxicity).

Table 3.2.1: Potential Adverse Effects as a Result of Exceeding Water Quality Criteria within a Mixing Zone, PBFs Potentially Affected, and Provisions of Alaska's Revised Mixing Zone Policy that Address those Effects.			
Potential Effects on Water Quality within a Mixing Zone - pollutant levels exceeding criteria which could cause...	**PBF(s) Potentially Affected**	**Provisions in AK's MZ Rule, 18 AAC 70.240, specific to addressing the identified effect**	**General Provisions in AK's MZ Rule, 18 AAC 70.240, relevant to addressing the identified effect**
acute water column toxicity	2, 3 *	(d)(7), (d)(8), (d)(1)	(c)(2), (c)(3), (c)(4)(D), and (c)(4)(F)
acute sediment toxicity	2,3 *	(d)(1)	(c)(2), (c)(3), (c)(4)(D), and (c)(4)(F)
chronic water column toxicity	2,3 *	(d)(1)	(c)(2), (c)(3), (c)(4)(D), and (c)(4)(F)
chronic sediment toxicity	2,3 *	(d)(1)	(c)(2), (c)(3), (c)(4)(D), and (c)(4)(F)
bioaccumulation to adverse levels	2,3 *	(d)(1)	(c)(2), (c)(3), (c)(4)(D), and (c)(4)(F)
adverse exposure to materials on the water surface	3*	(d)(4)	(c)(2), (c)(3), (c)(4)(D), and (c)(4)(F)
adverse physical alteration to the seafloor/benthic habitat	2*	d(3), (c)(4)(E)	(c)(2), (c)(3), (c)(4)(D), and (c)(4)(F)
biota to be attracted to a MZ, increasing the potential for adverse exposure to pollutants.	2,3*		(c)(2), (c)(3), (c)(4)(D), and (c)(4)(F)
biota to avoid a MZ, effectively reducing the availability of, or restricting movement within, critical habitat.	1,4	(c)(4)(G)	(c)(2), (c)(3), (c)(4)(D), and (c)(4)(F)
adverse effects from other potential stressors	2,3*		(c)(2), (c)(3), (c)(4)(D), and (c)(4)(F)
*Although the presence of pollutants exceeding water quality criteria, including pollutants at toxic levels, would be an impact to the quality of waters that fall within PBF 1, and could also potentially affect free passage between critical habitat areas, PBF 4, such affects would be a concern due to their impact on prey species and Cook Inlet belugas directly. Therefore, with the exception of avoidance, the potential for adverse effects due to pollutants exceeding water quality criteria is addressed in the analysis of potential effects to PBFs 2 and 3.			

Acute Toxicity in the Water Column and Sediment (PBFs 2 & 3)

The provisions at 18 AAC 70.240(d)(7) and 18 AAC 70.240(d)(8) address acute toxicity within a mixing zone, "within the mixing zone the pollutants discharged will not cause lethality to passing organisms," and "within the mixing zone the pollutants discharged will not exceed acute aquatic life criteria at and beyond the boundaries of a smaller initial mixing zone surrounding the outfall, the size of which shall be determined using methods approved by the department." These provisions address protection from acute exposures and lethality for organisms that pass through a mixing zone. This would include beluga whales and their prey species. Alaska's mixing zone implementation guidance (page 9) includes several specific approaches recommended in EPA's guidance for appropriately limiting the size of an initial acute mixing zone to prevent lethality to passing organisms, and specifies that if other methods are used to size an initial acute mixing zone, those methods "must be" comparable to those in EPA's Technical Support Document for Water Quality-based Toxics Control (EPA/505/2-90-001, March 1991).

The provisions at 18 AAC 70.240(d)(7) and 18 AAC 70.240(d)(8) do not provide protection from lethality for organisms that spend longer periods of time within the water column of an acute mixing zone, or sessile organisms occupying the benthic habitat within an acute mixing zone. However, 18 AAC 70.240(d)(1) addresses toxicity within a mixing zone more broadly, "within the mixing zone the pollutants discharged will not bioaccumulate, bioconcentrate, or persist above natural levels in sediments, water, or biota to significantly adverse levels, based on consideration of bioaccumulation and bioconcentration factors, toxicity, and exposure." "Significantly adverse levels" is defined at 18 AAC 70.990(54) of Alaska's water quality standards regulations as "concentrations of pollutants that would impair the productivity or biological integrity of the overall waterbody, including reducing or eliminating the viability or sustainability of a given species or community of species in the overall waterbody." When read in conjunction with the definition of "significantly adverse levels," the provision at 18 AAC 70.240(d)(1) is applicable at the species level and could be used to limit the extent to which acute toxicity would be a concern for sessile Cook Inlet beluga whale prey species and Cook Inlet beluga whale prey species that may be attracted to a mixing zone in designated critical habitat.

Restrictions on the location and size of mixing zones can be imposed to further protect sessile species from acute toxicity in mixing zones, as necessary to satisfy several more general provisions of Alaska's revised mixing zone rule. Those general provisions are 18 AAC 70.240(c)(2), 18 AAC 70.240(c)(3), 18 AAC 70.240(c)(4)(D), and 18 AAC 70.240(c)(4)(F), respectively, "...designated and existing uses of the waterbody as a whole will be maintained, and protected;" "...the overall biological integrity of the waterbody will not be impaired;" "the mixing zone will not result in a reduction in fish or shellfish population levels;" and "the mixing zone will not adversely affect threatened or endangered species except as authorized under 16 U.S.C. 1531 - 1544 (Endangered Species Act)." The provision at 18 AAC 70.240(c)(4)(D), "the mixing zone will not result in a reduction in fish or shellfish population levels," is perhaps most directly relevant to protecting the Cook Inlet beluga whale prey species.

Chronic Toxicity in the Water Column and Sediment (PBFs 2 & 3)

Alaska's revised mixing zone rule does not contain provisions that explicitly speak to chronic toxicity, other than 18 AAC 70.240(c)(4)(A) which prohibits mixing zones from resulting in acute or chronic effects outside of a mixing zone. It is generally thought that if mixing zones are properly located and sized, chronic criteria can be exceeded within a mixing zone without significant adverse effects to a waterbody's aquatic community. The provision at 18 AAC 70.240(d)(1), however, addresses toxicity within a mixing zone broadly, is applicable at the species level, and could be used to limit the extent to which chronic toxicity would be a concern for sessile Cook Inlet beluga whale prey species and Cook Inlet beluga whale prey species that may be attracted to a mixing zone in designated critical habitat (see the Acute Toxicity discussion for the text of 18 AAC 70.240(d)(1) and the associated definition of "Significantly adverse levels").

In addition, as is the case with regard to acute toxicity, restrictions on the location and size of mixing zones can be imposed to further protect sessile species from chronic toxicity in mixing zones, as necessary to satisfy the general provisions of Alaska's revised mixing zone rule at 18 AAC 70.240(c)(2), 18 AAC 70.240(c)(3), 18 AAC 70.240(c)(4)(D), and 18 AAC 70.240(c)(4)(F). Again, the provision at 18 AAC 70.240(c)(4)(D), which states "the mixing zone will not result in a reduction in fish or shellfish population levels," is perhaps most directly relevant to protecting Cook Inlet beluga whale prey species.

<u>Bioaccumulation</u> (PBFs 2 & 3)

The provision at 18 AAC 70.240(d)(1) of Alaska's revised mixing zone rule directly speaks to the control of bioaccumulative pollutants within a mixing zone, "within the mixing zone the pollutants discharged will not bioaccumulate, bioconcentrate, or persist above natural levels in sediments, water, or biota to significantly adverse levels, based on consideration of bioaccumulation and bioconcentration factors, toxicity, and exposure and within a mixing zone." "Significantly adverse levels" is defined at 18 AAC 70.990(54) of Alaska's water quality standards regulations as "concentrations of pollutants that would impair the productivity or biological integrity of the overall waterbody, including reducing or eliminating the viability or sustainability of a given species or community of species in the overall waterbody." As discussed under acute and chronic toxicity, the provision at 18 AAC 70.240(d)(7) is applicable at the species level and could be used to address potential adverse effects to Cook Inlet beluga whales and their prey species from bioaccumulation. Mixing zones can also be conditioned or denied to limit adverse effects due to bioaccumulation as necessary to satisfy the general provisions at 18 AAC 70.240(c)(2), 18 AAC 70.240(c)(3), 18 AAC 70.240(c)(4)(D), and 18 AAC 70.240(c)(4)(F).

<u>Adverse Physical Alteration to the Benthic Habitat</u> (PBF 2)

The potential for physical alteration that could adversely affect benthic habitat used by Cook Inlet beluga whales or their prey species can be addressed by controlling the size, location, and in-zone quality of mixing zones as necessary to satisfy the general provisions at 18 AAC 70.240(c)(2), 18 AAC 70.240(c)(3), 18 AAC 70.240(c)(4)(D), and 18 AAC 70.240(c)(4)(F). As with many of the other potential stressors, 18 AAC 70.240(c)(4)(D), "the mixing zone will not result in a reduction in fish or shellfish population levels," may be most directly relevant to protecting Cook Inlet beluga whale prey species. To the extent that physical alteration of benthic habitat could displace species, 18 AAC 70.240(c)(4)(E) is also applicable, "the mixing zone will not result in permanent or irreparable displacement of indigenous organisms."

The provision at 18 AAC 70.240(d)(3) could also be applicable, "within the mixing zone the pollutants discharged will not settle to form objectionable deposits, except as authorized under 18 AAC 70.210" (the provision at 18 AAC 70.210 is Alaska's "Zones of deposit" provision, which is a separate section of Alaska's water quality standards regulation and is not part of EPA's proposed action). While 18 AAC 70.240(d)(3) and the term "objectionable" are often viewed in terms of aesthetics, EPA believes that satisfying the provision could have overlap with protecting the biological functions of benthic habitat as well.

Attraction to Mixing Zones (PBFs 2 & 3)

Attraction to a mixing zone, such as due to temperature or organic solids that might provide a food source, could increase the potential for adverse exposure to toxic pollutants, both through extended water column exposure and through bioaccumulation as a result of feeding on contaminated material within a mixing zone. Alaska's revised mixing zone rule does not explicitly address attraction; however, mixing zones can be conditioned or denied to control this response as necessary to satisfy the general provisions at 18 AAC 70.240(c)(2), 18 AAC 70.240(c)(3), 18 AAC 70.240(c)(4)(D), and 18 AAC 70.240(c)(4)(F).

Avoidance Response to Mixing Zones (PBFs 1 & 4)

While avoidance of a mixing zone could protect species from exposure to harmful levels of pollutants, an avoidance response to a mixing zone in critical habitat could also have an adverse effect by reducing the availability of, or restricting movement within, critical habitat by both Cook Inlet beluga whales and their prey species. The provision at 18 AAC 70.240(c)(4)(G), "...the mixing zone will not form a barrier to migratory species or fish passage" provides a basis to condition or deny mixing zones to ensure that they do not prevent access to, or restrict movement within, critical habitat. Mixing zones can also be conditioned or denied to address avoidance as necessary to satisfy the general provisions at 18 AAC 70.240(c)(2), 18 AAC 70.240(c)(3), 18 AAC 70.240(c)(4)(D), and 18 AAC 70.240(c)(4)(F).

Adverse Effects from other Potential Stressors within Mixing Zones (PBFs 2 & 3)

In addition to toxic pollutants, mixing zones could be sought for other parameters, such as residues, dissolved gas, oil and grease, fecal coliforms, pH, temperature, turbidity, color, and biochemical oxygen demand/DO depletion. Some of these potential stressors are addressed above. For example, residues could adversely alter the physical benthic habitat within a mixing zone and temperature could attract species to a mixing zone. Where available, provisions of Alaska's revised mixing zone rule specific to the identified stressor can be used to limit potential adverse effects of exceeding water quality criteria within a mixing zone to Cook Inlet beluga whales and their prey species. In addition, the general provisions at 18 AAC 70.240(c)(2), 18 AAC 70.240(c)(3), 18 AAC 70.240(c)(4)(D), and 18 AAC 70.240(c)(4)(F) provide Alaska with broad authority to condition or deny mixing zones as necessary to avoid adverse effects from potential stressors.

Discussion of Primary Effects Analysis

For each of the potential stressors or adverse effects identified in Table 3.2.1, EPA has identified provisions of Alaska's revised mixing zone policy that could be implemented to prevent or minimize the effect. In many cases the provisions are specific to the identified effect, i.e., specific to addressing bioaccumulation or toxicity, and in all cases there are general provisions which EPA reads as providing Alaska with broad authority to condition or deny mixing zones as necessary to avoid adverse effects from potential stressors.

The general provisions that EPA identified in each case are 18 AAC 70.240(c)(2), 18 AAC 70.240(c)(3), 18 AAC 70.240(c)(4)(D), and 18 AAC 70.240(c)(4)(F). The provision at 18 AAC 70.240(c)(2) is, "...designated and existing uses of the waterbody as a whole will be maintained, and protected." EPA believes Cook Inlet beluga whales and their critical habitat both can be protected as part of the designated uses for

Cook Inlet and as an existing use. The provision at 18 AAC 70.240(c)(3) is, "...the overall biological integrity of the waterbody will not be impaired." Protecting the designated critical habitat for Cook Inlet beluga whales, such as the prey species specified in PBF 2, is relevant to both the species and the overall biological integrity of Cook Inlet. The provision at 18 AAC 70.240(c)(4)(D), "the mixing zone will not result in a reduction in fish or shellfish population levels" provides a clear mandate relevant to protecting the Cook Inlet Beluga whale prey species specified in PBF 2.

The provision at 18 AAC 70.240(c)(F) speaks to mixing zones and threatened or endangered species, "the mixing zone will not...adversely affect threatened or endangered species except as authorized under 16 U.S.C. 1531 - 1544 (Endangered Species Act)." EPA views 18 AAC 70.240(c)(F) as a recognition by ADEC that it does not have authority under state law to authorize adverse effects to threatened or endangered species, but can recognize adverse effects that are first authorized by the NMFS and USFWS in accordance with federal law/the Endangered Species Act. That is, while ADEC has no authority to itself authorize adverse effects to ESA species, ADEC has no obligation to be more stringent than federal law. For the purpose of this addendum to the biological evaluation, EPA is not considering 18 AAC 70.240(c)(F) as a state provision that prohibits adverse effects to ESA species. Nevertheless, EPA believes that 18 AAC 70.240(c)(F) at a minimum has value in that it should encourage communication between ADEC and NMFS about the possible effects of mixing zones, in an effort to ensure that potential adverse effects to Cook Inlet beluga whale critical habitat are addressed prior to mixing zone authorization.

While the identified provisions of Alaska's revised mixing zone policy for addressing potential adverse effects to Cook Inlet beluga whale designated critical habitat do not specify how protection will be achieved, Alaska must implement its mixing zone rule in a manner that satisfies the respective provisions. This in turn means that Alaska must limit mixing zone location, size, and in zone quality as necessary to prevent adverse effects, such as to prevent a reduction in fish or shellfish population levels as required by 18 AAC 70.240(c)(4)(D), which is directly relevant to PBF 2. Furthermore, 18 AAC 70.240 is clear that mixing zones are not an entitlement, i.e., "The department will approve, approve with conditions, or deny a mixing zone application." (emphasis added)

Alaska's mixing zone rule also contains a provision, 18 AAC 70.240(m), that recognizes the potential need to revisit mixing zone decisions to address adverse effects, "If the department finds that available evidence reasonably demonstrates that a mixing zone authorized by the department has had or is having a significant unforeseen adverse environmental effect, the department will terminate, modify, or deny renewal of the permit or certification authorizing the mixing zone."

3.3 Supplemental Effects Analysis

EPA's supplemental effects analysis focuses on a small subset of existing mixing zones within designated critical habitat that most closely aligned spatially with physical or biological features (PBFs) that are likely to be affected by mixing zones, and is further limited to a small subset of pollutants that may be discharged into mixing zones at concentrations exceeding water quality criteria. This analysis is intended to provide examples of what effects may occur to designated critical habitat within the footprint of a representative mixing zone. Additionally, the cumulative extent (total footprint) of existing mixing zones within designated critical habitat is discussed to provide an estimate of the magnitude of these effects.

As described earlier in the Approach to Effects Analysis section, EPA's supplemental effects analysis addresses only PBFs 1, 2 and 3 of Cook Inlet beluga whale designated critical habitat. Those PBFs relate to nearshore habitat in proximity to anadromous fish streams and by association primary prey species of beluga whale, and water quality. Authorization of mixing zones for facilities with discharges in critical habitat for the Cook Inlet beluga whale is not expected to affect the other two PBFs. As is also discussed in the Approach to Effects Analysis section, the evaluation of potential effects on PBFs is limited to within the bounds of the mixing zones where water quality criteria can be exceeded.

Because it's not practicable nor necessary to analyze all mixing zones within Cook Inlet, EPA focused on those that have the greatest likelihood of affecting PBFs, and then ultimately selected one as representative of other mixing zones within that particular category. As explained in the following sections, EPA selected the mixing zones that had the greatest likelihood of impact due the location of the discharge relative to the PBFs (as defined under Permit Information) and the volume and concentrations of pollutants discharged within the mixing zones.

Facilities with permitted discharges fall into six "categories" defined in terms of the Standard Industrial Classification codes included in each category. These categories include:

1. Seafood aquaculture and forestry
2. Air/sea transport, miscellaneous
3. Mining and oil/gas related
4. Water supply and wastewater related
5. Construction and development related
6. Placer mining

Not all the facility types listed above are assigned a mixing zone. According to discharge permit information provided by ADEC, three discharge categories have mixing zones in Cook Inlet: Category 1 - seafood aquaculture, Category 3 - oil and gas related, and Category 4 - wastewater related (Figure 3.3.1). The mixing zones considered in this supplemental analysis were associated with Categories 1 and 4.

The focus of EPA's previous consultation for the Cook Inlet Beluga whale was on effects from exposure to pollutants discharged by facilities with mixing zones (EPA 2006, 2009a; NMFS 2010). Because this BE addendum is a supplement to the previous consultations, and characterization of the pollutants in discharges into Cook Inlet have been described previously in detail (Section 4.2, EPA 2009a; Section 3.1.2 NMFS 2010), that information will not be repeated herein. Moreover, both EPA and NMFS's consultation documents included a discussion of the various types of existing mixing zones within Cook Inlet, the 2006a BE and 2010 Biological Opinion, respectively. The number of permitted discharges and the characteristics of those discharges has not changed significantly since those consultations were concluded.

This supplemental analysis is organized into the following sections:

- Section 3.3.1 contains permit information and a rationale for selecting the specific mixing zones contained in this analysis;
- Section 3.3.2 presents the chemical characteristics of the mixing zones and explains the effluent limitations that drove the mixing zones that were the focus of this analysis;

- Section 3.3.3 is a toxicity assessment and presentation of the process for determining risk to PBFs from exposure to the pollutants present in the chosen mixing zones;
- Section 3.3.4 presents the effects analysis for the PBFs of beluga whale critical habitat, and
- Section 3.3.5 presents the literature cited.
- Figures and tables referenced in the supplemental analysis are presented at the end of the section.

3.3.1 Permit Information

Information provided by ADEC indicated that there are approximately 45 active permits that authorize point source discharges with mixing zones within Cook Inlet. For the purpose of its supplemental effects analysis, EPA focused only on those facilities that met the following seven criteria:

1) discharging into Cook Inlet;
2) discharging into designated critical habit;
3) discharging within state waters;
4) discharging shoreward of the 30ft depth contour;
5) discharging within 5 miles of high and medium flow anadromous fish streams or rivers;
6) operating under an active permit, and
7) assigned a mixing zone.

This effort required obtaining accurate coordinates for the location of the discharge. This was not always possible and questions remain about the accuracy of some of the locations. A few of the facility locations were geo-located from their previously low accuracy positions, which were a few hundred feet from the actual discharge point, to a more accurate placement on the map. These facility locations were manually adjusted using an aerial imagery based "best- guess" method of placing the discharge or outfall on the border of the nearest waterbody that is also adjacent to the regulated facility it is assigned to.

The configuration and positioning of the discharge plumes within mixing zones is dictated by bathymetry and the hydrodynamics of the receiving water and are often long and narrow. Because the plume configuration and direction can change within tidal waters, EPA mapped the mixing zones as circles surrounding the point of discharge.

EPA mapped these facilities along with Cook Inlet beluga whale designated critical habitat and other features, which would facilitate the analysis of mixing zones on the PBFs identified in the critical habitat rule (76 FR 20180) (Figure 3.3.1). EPA then compiled NPDES permits, fact sheets and documents supplied by the discharger for a subset of these facilities which were the focus of this supplemental effects analysis.

Consistent with the language in PBF 1, EPA mapped the 30 ft depth contour and identified the location of anadromous fish streams. Once the mixing zones within proximity to anadromous fish streams and the 30 ft depth contour were located, the City of Kenai WWTP and seafood waste discharges were selected as a group for analysis. The seafood waste discharges and the City of Kenai WWTP are situated at the mouth of a highly important salmonid production watershed (Kenai River). The pipe for the Kenai

WWTP discharge is also exposed for brief periods during certain low tides increasing the likelihood of impacts to sediment dwelling organisms at the base of the food web.

The following sections provide an overview of pertinent information for seafood and municipal discharges in general, followed by information specific to each of these mixing zones.

3.3.1.1 Permit Information - Seafood Waste Discharges - Seafood waste discharges are covered under the NPDES Permit for Seafood Processors in Alaska issued by EPA in 2001 (EPA 2001). This permit is being reissued by the Alaska Department of Environmental Conservation (ADEC), and the draft permit is currently available for public comment on the State's website. The Kenai and Kasilof River Estuaries are receiving waters for six active permits to discharge seafood waste that may be affecting PBFs (Figure 3.3.1; Table 3.3.1). The majority (five) of these discharges are in the Kenai River, the sixth seafood waste discharge is in the Kasilof River Estuary.

The allowable mixing zone for seafood discharges under the Seafood General NPDES Permit (AKF52000) is a cylindrical shape with dimensions described as follows: the horizontal extent determined by a 100-foot radius around the terminus of the outfall, extending vertically up to the sea surface and extending vertically down to the seafloor. According to the Seafood General Permit (EPA 2001), mixing zones are provided for discharges of dissolved oxygen (DO), floating and suspended waste residues, color, turbidity, temperature, pH, fecal coliform bacteria, and total residual chlorine. Zones of deposit of one (1) acre are provided for settleable solid seafood processing waste residues.

Each of these six seafood waste discharges is provided a one-acre zone of deposit (ZOD) where materials can settle onto the sea floor resulting in localized effects on the benthic community, sediment and water quality. While the ZODs and Alaska's ZOD provision are not part of this consultation, the mixing zone allows for the discharge of the waste which can settle into a ZOD if flows in these rivers are not sufficient to disperse the waste material.

The loading of seafood waste discharged into the Kenai River Estuary is presented in Table 3.3.2. The discharge of seafood waste from facilities in the Kenai River is substantial with a total of 10 million pounds per year, with an additional 5 million pounds per year discharged to the Kasilof River. Four of these mixing zones allocated for seafood waste discharge in lower Kenai River are approximately 1,000 ft apart (Figure 3.3.2). According to the notices of intent (NOIs) for coverage under the general permit, these facilities also discharge other waste such as process disinfectants (surfactants), cooling water, boiler water, and transfer water and refrigeration condensate. Mixing zones for these discharges are at a depth of -10 ft and distance from shore ranges from 40 to 150 ft. The focus on seafood waste mixing zones in general was for seafood waste discharges in the Kenai River Estuary.

3.3.1.2 Permit Information - Municipal Wastewater Treatment Plant Discharges - There are two facilities discharging municipal wastewater into critical habitat that may be affecting PBFs; these facilities serve the cities of Anchorage and Kenai. The largest is the Asplund WWTP at Point Woronzof which discharges directly into Cook Inlet and is within proximity of the anadromous salmon water bodies of Fish Creek, Chester Creek, and Ship Creek. The City of Kenai WWTP discharges directly into Cook Inlet at the mouth of the Kenai River, an important spawning and rearing river for anadromous salmonids.

3.3.1.2.1 Asplund WWTP (AK0022551) – The Asplund facility discharges a large volume of effluent (34 mgd), after primary treatment. Predicting the dilution for this mixing zone is challenging because although the large tidal excursions provide substantial flushing that prevents the buildup of previously discharged wastewater in the vicinity of the discharge, the current patterns in Knik Arm can result in a long-term, quasi-steady state buildup of ambient wastewater concentrations. The long-term accumulation limits the dilution. Using the predicted ambient buildup concentrations during most restrictive low flow season results in a minimum effective initial dilution of 142:1 for conservative substances (Fact Sheet for NPDES Permit AK-002255-1).

The mixing zone for this facility is called a zone of initial dilution (ZID), and is 327 acres (assuming a circular mixing zone[1]) in size based on the maximum radius of 2130 ft. The extent of the plume was determined by plotting the trajectory of each of the three plumes from the diffuser and superimposing the width of each plume as predicted by the UDKHDEN model. Specifically, the length and width of the ZID (for each hourly interval) were determined from the UDKHDEN model output for the horizontal distance parallel to the ambient current and the plume diameter or width, respectively. The plumes are generally long and narrow; only at slack tides do they spread out, and then switch quickly when tidal directions change. The longest plumes to reach a density difference of 0.01 were about 2,130 feet. For most hours during the day, the width of the plume was less than about 165 feet. However, for slack tide, plume widths reached over 656 feet for the higher discharge rate.

The Asplund facility is currently undergoing substantial reanalysis by EPA in response to the request by the ADEC to renew the 301(h) waver of secondary treatment requirements under the Clean Water Act. Therefore, further analysis of this mixing zone is not included in this addendum.

3.3.1.2.2 City of Kenai WWTP (AK0021377) – The Kenai WWTP has a design flow of 1.3 million gallons per day (mgd) and an average monthly flow of 0.54 mgd discharged to Cook Inlet. The facility receives no significant industrial discharge, and the system has no combined sewers.

The treated effluent discharges through a 12-inch outfall pipe that runs 1,300 ft (457 m) from the facility to mean high water in Cook Inlet, on a line perpendicular from the shoreline. Due to the shallow receiving area the end of the effluent line is exposed during negative low tides for approximately two hours during each 12 hour tidal cycle on those occasions when there are lower minus tides (less than -2.0 ft), which represent about 14% of all the low tides within a year. When the outfall is exposed, there is no dilution until the effluent reaches the receiving water.

The permit fact sheet for the Kenai WWTP states that during negative low tides the exposed area is the half circle of the radius of the acute (7 m) and chronic (150 m) mixing zones, i.e., 0.001 km^2 and 0.035 km^2, respectively. Within these areas the pollutants in the effluent are discharged directly onto the sediments. Those hydrophobic or ionic pollutants will adhere to ionizable functional groups within organic matter in the sediments increasing pollutant concentrations and potentially the availability of pollutants to sediment dwelling organisms. Given that the average monthly flow is 0.54 mgd and the end of the outfall is exposed for 2 hours during each 12 hour tidal cycle for 14% of the yearly tidal cycles, then 4.1 mg/yr of effluent are discharged directly onto the sediments. During these times when the

[1] Formula for the area of a circle: $A = \pi r^2$

pipe is exposed, ADEC predicted a dilution ratio of 18:1, this was the dilution used to establish the chronic mixing zone in the permit.

3.3.2 Chemical Characteristics of the Mixing Zones and Establishment of Water Quality Based Effluent Limitations

The stressors associated with the permitted discharges presented in Table 3.3.3 vary by material, physical characteristics and complexity. Seafood processing discharge can result in physical stressors generated by large volumes of material discharged, which can be long-lasting and create adverse physical and biological effects on water quality and benthic habitat if not dispersed. Depending on the level of treatment, municipal wastewater can have various effects on water quality, including impacts to the aquatic food web due to the toxicity of pollutants and bioaccumulation of hydrophobic pollutants.

For point source discharges, the CWA requires that the effluent limitations for a particular pollutant be the more stringent of either technology-based treatment requirements or water quality-based effluent limits (WQBELs). Technology-based requirements, in short, are set according to the level of treatment determined to be achievable by a group of discharges with common characteristics using available technology, regardless of the assimilative capacity of any particular waterbody that may receive a discharge. WQBELs are established on a case-by-case basis when either technology-based requirements do not exist for the pollutants of concern or are not stringent enough to ensure that the water quality standards of a waterbody are will be met.

The permitting authority first determines which technology-based requirements apply to the discharge in accordance with applicable national effluent guidelines. The permitting authority further determines which WQBELs apply to the discharge based upon an assessment of the pollutants discharged and a review of state water quality standards. Effluent limits are to be based on the more stringent of the technology-based or water quality-based requirements. Monitoring requirements must also be included in the permit to determine compliance with effluent limitations. Additional effluent and/or ambient monitoring may also be required to gather data for future effluent characterization and permit development.

If in the preparation of a NPDES permit the permit writer has determined that a pollutant or pollutant parameter is discharged at a level that will cause, have reasonable potential to cause, or contribute to an excursion above any state water quality standard, the permit writer must develop WQBELs for that pollutant parameter. This "reasonable potential" determination may take into account dilution of the effluent pollutant concentrations upon discharge to the receiving water, through allowance of a regulatory mixing zone. WQBELs are established for those pollutants that would exceed water quality criteria at the edge of the mixing zone.

The identification of pollutants in a discharge for which WQBELs may be established is based on effluent monitoring data reported in the discharger's NPDES permit application, discharge monitoring reports and special studies. In addition, the permitting authority might collect data itself through compliance inspection monitoring or other special study. Permit writers match information on which pollutants are present in the effluent to the applicable water quality standards to identify parameters that are candidates for WQBELs. The consideration of the need for WQBELs is generally limited to those pollutants for which EPA has developed numeric water quality criteria guidance that the State has adopted into its water quality standards. There are many chemicals in wastewater discharges, such as those in food additives, personal care products, beauty aids and pharmaceuticals, for which numeric water quality criteria have not been developed, discharge monitoring data are few or nonexistent, and effluent limitations are not established.

While a WQBEL may in certain cases require water quality criteria to be met at the point of discharge, often WQBELs reflect the allowance of dilution in a regulatory mixing zone. The focus of this analysis was on those pollutants which were identified as requiring WQBELs after an allowance of a mixing zone, and the effect that exceeding water quality criteria within a mixing zone may be having on the PBFs of beluga whale designated critical habitat.

3.3.2.1 Physical and Chemical Characteristics of Seafood Waste - Waste discharged by seafood processors is composed of a combination of a dissolved portion consisting of ammonia, fats, oils and grease (FOG), nutrients, and solids (particles of shell, muscle, skin, organs, and bone); these are considered the major pollutants in seafood waste discharges. Regulations require that the solid fraction be ground to a particle size of 1.3 cm. Studies have found high biochemical oxygen demand (BOD), oil and grease, and nitrogen characterize effluents from seafood processing facilities. Most of the BOD and total suspended solids (TSS), and approximately 60 percent of the oil and grease present in the discharge originate from the butchering process (NovaTec and EVS 1994). The chemical composition of this waste depends on the amount of protein, fat, bone, chitin, and connective tissue present. Elevated nitrogen content, for example, has been attributed to high blood and slime content in seafood processing effluents.

In addition to BOD, TSS, FOG, and ammonia, other contaminants can be present in effluent from seafood processing facilities. Pollutants such as chlorine, ammonia, surfactants and most other chemicals associated with seafood waste are potentially mobile in the water column and could be transported beyond areas of heavy deposit. Permits may include discharge limits for some of these pollutants and these parameters may not exceed State water quality standards outside of authorized mixing zones. In addition to the residues themselves, biological degradation of the organic component of the residue can release chemical compounds, such as ammonia or hydrogen sulfide, into the water and affect the level of DO in quiescent waters. These compounds will be present in various levels in both the water above the sediments and in the interstitial waters within the sediments. Depending on the concentrations, organisms exposed to these compounds can experience acute toxicity or sublethal effects.

Potential adverse impacts on receiving water quality resulting from seafood processor wastes include reduction in water column DO due to the decay of particulate and soluble waste matter; the release of toxic levels of sulfide and ammonia from decaying waste; nutrient enrichment and stimulation of phytoplankton growth and alteration of the phytoplankton community; and the accumulation of waste solids and fish oils on the water surface, shorelines, and the bottom. All of these water quality impacts subsequently affect the biological communities present in the area of the discharge.

Water quality criteria for residues, dissolved gas, oil and grease, fecal coliform, pH, temperature, turbidity, color and total residual chlorine may be exceeded within these mixing zones. Seafood waste discharges are covered under a general permit and unlike municipal waste mixing zones, WQBELs are not set nor is site specific dilution calculated making it difficult to predict the concentrations of pollutants to which PBFs may be exposed.

Chlorine and ammonia are two pollutants common to both municipal and seafood waste discharges. We discuss chlorine under seafood waste discharges as it is relevant here and not under the particular mixing zone that was assessed for municipal discharge; the rationale will become clear later in the document.

3.3.2.1.1 Chlorine - The toxic mechanism(s) of action of residual chlorine to aquatic life are not fully understood, but are likely related to the ability of chlorine to oxidize organic matter. Intracellular enzymes containing sulfhydryl groups are oxidized almost immediately by residual chlorine in both plants and animals. Due to the strength of the chemical bond formed between chlorine and proteins, enzyme activity is irreversibly terminated. This irreversible nature of chlorine reacting with enzymes likely explains the observed irreversible toxicity of chlorine to fish once equilibrium has been lost (Alabaster and Lloyd 1982).

In fish, gills are believed to be the primary site of toxic action of chlorine. This is based on multiple observations of damage to gill epithelium following exposure to chlorine. Cairns et al. (1975) concluded that the mode of toxic action of chlorine to fish is gill tissue damage combined with accumulation of mucus on the gills. The combination of physical damage to gill tissue and coating of gill tissue by mucus inhibits oxygen uptake, resulting in suffocation of the fish.

If the mechanism of toxic action proposed by Cairns et al. (1975) is correct, chlorine is one of the relatively few chemicals that does not require an internally bioaccumulated dose to elicit toxicity to aquatic life. The mechanism of toxic action of chlorine limits the exposure of both fully aquatic and aquatic-dependent species to chlorine, as it precludes exposure via the dietary ingestion exposure route.

The reactivity of chlorine with other substances found in aquatic systems, combined with the volatility of chlorine gas limits both the concentration and residence time of chlorine in aquatic systems. Unlike most other chemicals discharged to aquatic systems, sediments do not serve as a sink for chlorine. Sediment is therefore not a medium by which aquatic species are exposed to chlorine. The combination of these factors also serves to limit the complete and significant exposure pathway of aquatic species to chlorine discharged to surface waters to direct contact, primarily with respiratory surfaces of aquatic species.

3.3.2.2 Chemical Characteristics of Municipal Wastewater - The discharge of municipal wastewater effluent is known to affect water quality in the receiving water body. The degree to which water quality is diminished is directly related to the level of treatment and the baseline water quality. In addition to BOD, TSS, ammonia, phosphorus, chlorine and metals, municipal effluent has been shown to contain trace amounts of many chemicals found in a variety of products that are disposed of via municipal sewer systems and through industrial discharges. While we acknowledge that many pollutants are discharged in municipal wastewater, the majority have no numeric water quality criteria and monitoring is not required in NPDES permits. Without pollutant effluent concentrations it's not possible to develop with any certainty the exposure point concentrations for beluga whale prey species and ultimately predict risk. Therefore, as previously discussed this analysis focuses on those pollutants which were drivers for establishing the mixing zones and, as a result, were assigned a water quality based effluent limitation (WQBEL) in the NPDES permit.

According to the fact sheet for the Kenai WWTP permit there are WQBELs for ammonia and copper because there was reasonable potential for these pollutants to exceed water quality criteria at the boundary of the chronic mixing zone. The permit requires monitoring of the effluent for BOD, TSS, fecal coliform bacteria, pH, ammonia, copper, flow, and total residual chlorine to determine compliance with the effluent Limitations.

The monitoring of effluent for arsenic, cadmium, and silver was removed from the 2015 permit. In addition, the permit includes requirements to monitor the effluent for enterococci bacteria, zinc, and whole effluent toxicity (WET) in order to conduct future reasonable potential analysis to determine if discharges might cause an exceedance of applicable water quality criteria in the receiving water body. Thirteen effluent samples were taken during the 2008 permit cycle and analyzed for arsenic, cadmium and silver. Results for all three metals were reported in the effluent at concentrations well below the applicable water quality criteria. The effluent limitations for chlorine were set at the water quality criteria for chlorine, without an allowance for dilution in a mixing zone. This analysis included an evaluation of ammonia, a representative pollutant for which a regulatory mixing zone was established.

The situation at the Kenai WWTP is unique in that the discharge pipe is exposed during some low tidal periods; at these times there is no dilution occurring. Table 3.3.4 presents the loading of ammonia and copper on a monthly and yearly basis, which is used to calculate the loading during those times when the pipe is exposed. Based on maximum discharge, the amount of ammonia and copper that would be discharged directly onto the substrate is 157 and 195 lbs, respectively. When the average discharge is considered this amount drops considerably to 21 lbs and 1.2 lbs for ammonia and copper, respectively.

Information on the presence or absence of indigenous organisms; acute or chronic toxic effects in the sediments; and bioaccumulation were not available to assess consistency with provisions such as AAC 70.240(c)(4)(A), (c)(4)(E), and (d)(1) of the revised rule. Absent sediment or biota monitoring data, it is difficult to draw conclusions about adverse effects on the benthic community within critical habitat. However, it is possible that benthic organisms are being adversely affected within the acute mixing zone and a portion of the chronic mixing zone due to the absence of dilution when the outfall pipe is exposed and metals and other pollutants are discharged directly onto sediments.

3.3.3 Toxicity Assessment for pollutants with Water Quality Based Effluent Limitations.

As previously described, EPA selected to analyze a municipal discharge (Kenai WWTP) and seafood discharges in the lower Kenai River which may be adversely affecting designated critical habitat. Seafood waste discharges reviewed are not assigned WQBELs, so only a discussion of municipal wastewater discharged from the Kenai WWTP is in the following sections.

3.3.3.1 Toxicity test data - The objective of this assessment was to determine the potential for adverse effects on fish and invertebrates exposed to those pollutants (ammonia and copper) which were assigned WQBELs for municipal wastewater discharge. EPA chose ammonia as a representative pollutant to present this illustration and relied on two primary sources of toxicity information: 1) toxicity test data presented in EPA's 304(a) aquatic life criteria (ALC) documents, and 2) data obtained through EPAs ECOTOX database published after the promulgation of the specific criteria. The illustration was not repeated for copper, but like ammonia, the effects concentrations for certain aquatic species may be exceeded at times within the mixing zone.

Through EPA's criteria development process, all data available at the time on a particular chemical were evaluated and only those data generated from sufficiently standardized and repeatable studies were included. In order to ensure that we were using the most current science, we searched EPA's ECOTOX database for toxicity tests that were conducted after the development of the ALC documents up to the present time (1989 to 2016). Consistent with the process for selecting studies for the development of ALC, the studies obtained through this search were evaluated for quality using EPA Office of Water test acceptability guidelines (EPA 1985) to determine suitability for use in this analysis.

3.3.3.2 Prediction of exposure point concentrations - The assignment of WQBELs for ammonia (based on criteria for un-ionized ammonia (UIA) as explained later) through the reasonable potential analysis made it possible to approximate exposure point concentrations for fish and invertebrates exposed to this pollutant in surface water within the mixing zone (Figure 3.3.3). In order to determine likelihood of exposure to UIA concentrations exceeding aquatic life criteria within the mixing zone, we predicted the reasonable worst case concentrations. EPA used the maximum daily discharge effluent limit (see Table 3.3.4) along with the receiving water background concentration to predict dilution-with-distance from the CORMIX model output from ADEC's mixing zone analysis. Rather than using one dilution level (18:1)[2] to calculate exposure point concentrations for the entire mixing zone, EPA calculated the weighted average for UIA to anticipate the exposure point concentrations for sessile or resident organisms that may be present within limited areas of the mixing zone. The output of this model allowed an estimate of pollutant concentrations at different locations within the mixing zone radius for UIA (Figure 3.3.3).

Using this approach, the UIA concentrations range from 1.2 mg/L to 0.2 mg/L and it takes approximately 12.5 minutes for full dilution to occur at the edge of the chronic mixing zone. Figure 3.3.4 presents travel time of the UIA plume from the point of discharge to the edge of the 150 m mixing zone. Additionally, the concentrations of UIA are presented at regular distances (20 m) from the point of discharge, these data were generated using the moving weighted average concentration and the CORMIX model (Figure 3.3.5).

3.3.3.3 Estimate of risk – EPA identified available acute and chronic effect concentrations for saltwater organisms that may occur, or that represent those organisms that may occur, in the mixing zone and may also serve as beluga prey items. This was done to understand the organism's relative sensitivity to pollutant (e.g., ammonia) exposures. By comparing effect concentrations to modeled mixing zone concentrations, EPA was then able to assess the potential impact of pollutant concentrations within the mixing zone on a typical saltwater community, with additional emphasis on beluga prey items or close surrogate species.

Effect concentrations used in this analysis were obtained from the open literature and primarily from EPA's latest available 304(a) ambient water quality criteria recommendations pertaining to aquatic life, which are based on the Guidelines for Deriving Numerical National Water Quality Criteria for the Protection of Aquatic Organisms and Their Uses (EPA 1985, hereafter the 1985 Guidelines). Broadly, the 1985 Guidelines outline a methodology that assesses high-quality toxicity tests to acquire acute (LC_{50}) and chronic (such as NOEC and EC_{20}) effect concentrations and identifies the acute and/or chronic effect concentration associated with the 5th centile of tested genera (LC_{50} = the concentration that resulted in lethality to 50% of the test organisms; NOEC = no observed effects concentration statistically different from the control; and EC_{20} = the concentration that resulted in an effect to 20% of the test organisms). The acute effect concentration, expressed as an LC_{50}, associated with the 5th centile of tested genera (final acute value or FAV) is then divided by a factor of 2 to represent an acute low effect level (criterion

[2] ADEC calculated a dilution of 18:1 was necessary for pollutants to be below chronic criteria at the edge of the mixing zone based on the WQBELs.

maximum concentration or CMC), so acute criteria concentrations do not represent values that resulted in 50 percent mortality. Dividing the LC_{50} by 2 converts a value that represents 50 percent mortality to a value that is intended to represent a low level of morality that is still statistically different than the control mortality, i.e. LC_{Low}. The final chronic value (FCV) concentration associated with the 5th centile of tested genera is generally derived by dividing the FAV by an acute to chronic ratio (ACR), and serves as the chronic criteria concentration (criterion continuous concentration or CCC) (EPA 1985). The FCV for the national saltwater ammonia ALC recommendation was derived in this manner.

Likewise, in the analysis here, a FCV was calculated for each individual species by dividing the species mean acute values (SMAV) expressed as LC_{50} values by the ACR reported in the national ALC documents for saltwater ammonia to predict the level of chronic effects on species within the mixing zone. This approach to establishing chronic effects concentrations is explained further in the following paragraph.

Typically, acute toxicity values are more prevalent than chronic toxicity values given the logistical challenges associated with long-term chronic toxicity testing. As a result, the 1985 Guidelines provide a methodology for estimating chronic effect concentrations from acute effect concentrations through the use of ACRs. ACRs relate the acute and chronic toxicities of a pollutant from toxicity studies in which both acute and chronic tests were conducted for the same species. By considering the distribution of all species-level ACRs, the 1985 Guidelines outline various methods that can be used to select an appropriate final ACR (FACR). Specific methods used to determine FACRs are based on the distribution and underlying trends across ACRs and are further discussed in the 1985 Guidelines (EPA 1985; pg. 21-22). A FACR can then be applied to acute effect concentrations to produce a corresponding chronic effect concentration.

Specifically, acute effect concentrations considered in this effect assessment were obtained from two broad sources:

1. LC_{50} values reported in corresponding aquatic life criteria document
2. LC_{50} values reported in open literature and EPA's ECOTOX database (published after criteria were finalized and met 1985 Guidelines test acceptability standards)

LC_{50} values were then divided by 2.0 to adjust the concentration to a $LC_{Low.}$

The chronic effect concentrations considered in this effects assessment were also obtained from two broad sources:

1. LC_{50} values reported in corresponding aquatic life criteria document divided by the FACR reported in the corresponding aquatic life criteria document
2. LC_{50} values reported in open literature and EPA's ECOTOX that were published after criteria were finalized and met 1985 Guidelines test acceptability standards, subsequently divided by the FACR reported in the corresponding aquatic life criteria document.

This supplemental analysis is not applicable for assessing the protectiveness of aquatic life criteria; rather, it is intended to predict and illustrate the level of effects that may be experienced by species considered PBFs of critical habitat when exposed to pollutants in mixing zones. Furthermore, this analysis is also intended to illustrate how pollutant concentrations within the mixing zone decrease with increasing distance from the discharge point to reach criteria concentrations at the edge of the mixing zone.

3.3.3.4 Species Sensitivity Distributions – Species sensitivity distributions (SSDs) are models of the variation in sensitivity of species to a particular stressor (Posthuma et al. 2002). SSDs are generated by fitting a statistical or empirical distribution function to the proportion of species affected as a function of stressor concentration or dose. Traditionally, SSDs are created using data from single-stressor laboratory toxicity tests, such as median lethal concentrations (LC_{50}s).

Using the data and methodology described above, EPA constructed SSDs to display the range of pollutant concentrations that result in acute and chronic effects for saltwater organisms that may occur, or that represent organisms that may occur, in the mixing zone and may also serve as beluga prey items. The ammonia SSD was constructed using the acceptable SMAVs (LC_{50} values), the LC_{Low} values (SMAV/2), and the FCVs (SMAV/ACR). The CORMIX modeled pollutant concentrations at increasing incremental distances from the discharge point were also plotted.

EPA integrated the concepts presented in this subsection to predict and illustrate the level of effects potentially experienced by species considered PBFs of critical habitat when exposed to pollutants in mixing zones and describe the magnitude of effects when exposed to ammonia in the following sections.

3.3.3.5 Ammonia - Ammonia is produced endogenously by fish primarily via the degradation of protein, and specifically through the removal of an amino group from various amino acids. Ammonia is extremely water soluble and under normal conditions easily excreted by fish across the gills. This ability to excrete ammonia is disrupted when the endogenous and exogenous ammonia concentrations are out of balance. This may be the case when the surface water ammonia levels are elevated making it difficult to excrete ammonia (analogous to osmosis). When exposed to elevated ammonia fish experience respiratory distress due to prevention of exchange of respiratory gasses at the gill surface or by inhibiting the transport of oxygen in combination with hemoglobin (Willingham 1976). Extended exposure (6 weeks) to low levels (0.002 mg/L) of UIA affected the physiology of salmonids resulting in reduced stamina, performance and growth (Burrows 1964; as cited in Willingham 1976). Gill hyperplasia affecting oxygen transport was also demonstrated in salmon exposed to 0.005 mg/L UIA. Gill hyperplasia reduces the surface are of the gills, reducing gas exchange and consequentially respiration. Gill infections are also common, frequently observed in fish rearing units. Both conditions affect physiology and fitness of the individuals.

The total ammonia concentration is the sum of NH_3 and NH_4^+. The toxicity of aqueous ammonia solutions to aquatic organisms is primarily attributable to the un-ionized form, the ammonium ion being less toxic (Armstrong et al. 1978; Chipman 1934; Tabata 1962; Thurston et al. 1981; Wuhrmann et al. 1947; Wuhrmann and Woker 1948; all as cited in EPA 1989). It is necessary, therefore, to know the percentage of total ammonia which is in the un-ionized form in order to establish the corresponding total ammonia concentration toxic to aquatic life. The percentage of UIA can be calculated from the solution pH and pKa *, the negative log of stoichiometric dissociation. EPA used the calculator developed by the Florida Department of Environmental Protection (FDEP)[3] to convert total ammonia to UIA according to salinity, pH and temperature (Figure 3.3.6). The salinity, pH and temperature we used in this calculation were the values presented in the Kenai WWTP Fact Sheet and were those used by the State in the Reasonable Potential calculation for the WQBEL limits: pH 8.2, Temperature 11 ^{0}C and salinity 20 ‰.

[3] http://www.dep.state.fl.us/labs/library/index.htm#Laboratory Methodologies

The methodology presented by FDEP differs somewhat from the equation EPA used in the 1989 saltwater ammonia ALC development document, but we chose the FDEP approach as it was easier to employ and resulted in a difference of only 0.002 and 0.004 mg/L. Given the level of uncertainty associated with this analysis that level of precision was acceptable.

Water quality, particularly pH and temperature, but also salinity, affects the proportion of UIA. With freshwater species, the relationship between the toxicity of UIA and pH and temperature is similar for most species and was used to derive pH and temperature dependent freshwater criteria for Ammonia. According to the ALC development document for saltwater ammonia, the available data provide no evidence that temperature or salinity have a major or consistent influence on the toxicity of ammonia. Hydrogen ion concentration does increase toxicity of ammonia at pH below 7.5 in some, but not all species tested; above pH 8, toxicity may increase, decrease, or be little altered as pH increases, depending on species. The pH of seawater is approximately 8.0 (8.2 was used in the Kenai WWTP Alaska Pollutant Discharge Elimination Permit System (APDES) permit).

EPA ensured that all comparisons, WQBELs, toxicity test data and effects levels were reported as UIA. Initially, we normalized the total ammonia WQBEL reported in the APDES permit to the un-ionized form using the FDEP calculator and conditions specified in the permit for Cook Inlet waters (pH 8.2; Temperature 11^{0}C, and salinity 20 ‰) to arrive at a discharge concentration (Figure 3.3.6). When toxicity test data from the literature were reported as total ammonia, we converted this to UIA based on pH, temperature and salinity reported in the toxicity test. We did not normalize the toxicity test data to conditions within Cook Inlet. Unlike the effect concentrations from which it is based, the 1989 saltwater ammonia criteria is pH and temperature dependent. This dependence is not meant to reflect the influence of pH and temp on UIA toxicity but rather, to reflect the influence of pH and temperature on the proportion of total ammonia that is most toxic (i.e., un-ionized) at a particular site.

3.3.3.5.1 Summary of Toxicity Test Data 1989 Saltwater Ammonia Aquatic Life Criteria Document - The 1989 ALC document includes the review of the acute and chronic toxicity for UIA. Data were available on the acute toxicity of UIA to 21 saltwater animals in 18 genera with LC_{50} concentrations ranging from 0.23 to 43 mg NH_3/L. Fish and crustaceans are well represented among both the more sensitive and more resistant species; mollusks are generally resistant. The larval winter flounder (Pseudopleuronectes americanus), is the most sensitive fish species, with a mean LC_{50} of 0.492 mg/L. Species mean acute values for seven crustaceans ranged from 0.773 mg/L for the Sargassum shrimp (Latruetes fucorus) to 2.21 mg/L for the American lobster (Homarus americanus). The adult eastern oyster (Crassostrea virginica) were the least sensitive with an LC_{50} of 19.1 mg/L.

It's challenging making clear distinctions in sensitivity to UIA based on taxonomy or environmental variables due in part to toxicity test variability. As stated previously, pH has a significant influence on the proportion of UIA as does the condition of the test organism. The ALC document reports that intra and inter laboratory comparisons of acute toxicity test results using saltwater species show LC_{50}s may differ by as much as a factor of two for the same chemical tested with the same species (Hansen 1984; Schimmel 1986; both cited in EPA 1989). In light of all these sources of variability, LC_{50}s for UIA that are in this document are considered similar unless they differ by at least a factor of two.

Few marked differences are evident in the acute toxicity of ammonia with respect to differences in life stage or size of the test organism with LC_{50}s ranging from 0.33 mg/L to 1.66 mg for yolk-sac stages of larvae and juvenile striped bass (Morone saxatilis) (Poucher 1986; EA 1986; Hazel et al. 1971; both cited in EPA 1989). Acute values for striped mullet (Mugil cephalus) suggest a factor of two decrease in sensitivity (LC_{50} - 1.19 vs. 2.38 mg/L) to ammonia with increase in weight from 0.7 to 10.0 g (Venkataramiah et al. 1981; cited in EPA 1989). Larval grass shrimp (Palaemonetes pugio) appear to be more acutely sensitive (LC_{50} - 1.06 mg/L) (EA 1986; cited in EPA 1989) than juveniles and adults (LC_{50} - 2.57 mg/L) (Fava et al. 1984; cited in EPA 1989).

The number of chronic toxicity tests that have been conducted on ammonia with saltwater species is limited (2 of the 12 tests conducted). In saltwater, a 32-day life-cycle toxicity test and a 28-day early life-stage test were conducted with the mysid (Mysidopsis bahia), and inland silverside (Menidia beryllima), respectively.

The effect of ammonia on survival, growth and reproduction of *M. bahia* was assessed in a life-cycle toxicity test lasting 32 days (Cardin 1986; cited in EPA 1989). Survival was reduced to 35 percent of that for controls and length of males and females was significantly reduced in 0.331 mg/L. Although reproduction was markedly diminished in this concentration, it did not differ significantly from controls. Lengths of females were significantly reduced in 0.163 mg/L, but this is not considered biologically significant since reproduction was not significantly affected. No significant effects on mysids were detected at 0.092 mg/L. The chronic limits are 0.163 and 0.331 mg/L for a chronic value of 0.232.

The effect of ammonia on survival and growth of the inland silverside (*M. beryllima*) was assessed in an early life-stage test lasting 28 days (Poucher 1986; cited in EPA 1989). Fry survival was reduced to 40 percent in 0.38 mg NH_3/L, relative to 93% survival of control fish, which is a significant difference. Average weights of fish surviving in concentrations > 0.074 mg/L were significantly less than weights of controls, an effect which persisted as the concentration of ammonia increased. No significant effects were detected in silversides exposed to 0.050 mg/L. Thus, the chronic results of 0.050 and 0.074 mg/L yielded a chronic value of 0.061 mg/L.

3.3.3.5.2 Summary of Toxicity Test Data from the EPA ECOTOX Database between 1989 and 2016 - The ECOTOX database included the review of primarily acute toxicity for UIA (in some cases it was necessary to convert from total ammonia). The ECOTOX search revealed seven studies on fish and invertebrates exposed to ammonia. Two of the seven studies were written in Chinese and Portuguese and were not translated for use here. Unfortunately, the data for what appeared to be the most sensitive species (blood clam, *Anadara broughtonii*) was presented in a paper written in Chinese. The remaining five studies were evaluated using the EPA Test Acceptability Standards to determine whether they were applicable for use in this analysis. One (Kohn et al. 1994) of the five studies was deemed acceptable for use in this analysis, the other studies were rejected based on multiple criteria.

Three of the four tests reported in Kohn et al. (1994) were included in this analysis. Kohn et al. (1994) evaluated the toxicity of ammonia to benthic amphipods commonly used in sediment toxicity tests (*i.e., Rhepoxynius abronius*, *Ampelisca abdita*, *Grandidierella japonica* and *Eohaustorius estuarius)*. The test using *A. abdita* was rejected because of unacceptable mortality (>90 %) in the control group and the remaining three amphipod tests were included. These species are important prey items for higher trophic level species and have different exposure pathways (pore water and sediment). The *R. abronius* was the most sensitive; with an LC_{50} of 1.59 mg/L (1.46 – 1.72 mg/L) followed by *E. estuarius* 2.49 mg /L (2.26 – 3.38 mg/L) and *G. Japonica* LC_{50} 3.35 (3.05-4.45 mg/L). These species fall within the range of crustaceans presented in the ALC document (0.77 - 3.35 mg/L).

Beluga whale prey consists of a wide variety of species both fish and invertebrates. These two groups are exposed to pollutants within mixing zones in very different ways. Fish are exposed to pollutants within the water column briefly while swimming through the mixing zones at rates that depend on the size of the mixing zone and the swimming speed of the species. Sessile organisms or those will small home ranges undergo chronic exposure when their presence overlaps with mixing zones. The impact of this prolonged exposure is directly related to the concentrations of pollutants discharged and the proximity of the organisms to the point of discharge. When these species are filter feeder (mollusks) or detritivores (crustaceans) exposure through the dietary pathway exists as well.

3.3.3.5.3 Ammonia Species Sensitivity Distribution – The SSDs for UIA are presented in Figures 3.3.7 through 3.3.9. EPA constructed SSDs to display the range of UIA concentrations that result in acute and chronic effects for saltwater organisms that may occur in the mixing zone and may also represent beluga prey items. EPA prepared each SSD utilizing the acceptable SMAVs (LC_{50} values), the LC_{Low} values (SMAV/2), and the FCVs (SMAV/ACR) based on the open literature and EPA's 1989 saltwater ammonia ALC development document (Figure 3.3.7; Table 3.3.5).

In addition, EPA calculated the concentration of ammonia at 20 m distance increments from the discharge point in order to relate the effect levels on a spatial scale within mixing zone (Figure 3.3.5). The chronic mixing zone is defined as the area within a circle, 150 meter radius, centered on the end of the outfall pipe and extending from the marine bottom to the surface. The chronic mixing zone for this discharge at times when the end of the pipe is not under water due to tidal fluctuations, is defined as the area within a half-circle of 150 meter radius, centered on the point where the effluent enters marine water. The dilution available within the half circle of 150 meter radius is 18:1 and was used by ADEC as the chronic mixing zone dilution factor.

The 18:1 dilution factor is calculated as being achieved by the edge of the mixing zone and less dilution/gradations of dilution are expected within the zone. Therefore, we attempted to characterize the change in the concentration of UIA as it moves within the plume away from the point of discharge (Figure 3.3.5). Because ADEC performs this exercise in determining if WQBELs are needed to ensure that water quality criteria are met at the edge of the mixing zone, it is expected that the concentration of UIA at the edge of the chronic mixing zone will be equal to or less than the chronic criteria (0.035 mg/L); and according to the COMIX modeling output generated by ADEC this is the case. However, for our purposes we predicted the concentrations at distance intervals in order to examine the exposure of less mobile or sessile organisms to UIA in the mixing zone and draw conclusions on the likelihood for adverse effects.

The following results are based not on uniform dilution considered in the States reasonable potential to exceed calculations when determining the need for WQBELs, but on EPA's moving weighted average estimates using the same CORMIX data output. Using the State's approach, the chronic ALC is achieved at the edge of the 150 m mixing zone (Figure 3.3.8).

The slope of the SSDs are steep with 86 percent of the species LC_{Low}s falling within an order of magnitude (0.5 to 5.0 mg/L) UIA (Figure 3.3.9). This indicates that there is a narrow concentration range in toxicity for a variety of species, but no one species group stands out as clearly being the most sensitive. The LC_{Low} for 50 percent of the species tested ranges from 0.49 to 1.54 mg/L. The four most sensitive species are two fish (winter flounder and red drum (*Sclaenops ocellatus)*) and two crustaceans (Sargassum shrimp and prawn), mollusks appear to be the least sensitive group.

The amount of low level mortality (LC_{Low}) anticipated to result from exposure to UIA in the mixing zone ranges from 58 to <1 percent of the species between the point of discharge and the edge of the chronic mixing zone (Figures 3.3.11). This low level mortality is dependent upon the duration of exposure, which is 96-hrs in standard toxicity tests (and for the data cited herein). Some level of toxicity occurs prior to 96-hrs but without the dose-response curve it's difficult to ascertain, and the raw data are rarely reported in test publications.

Unless a species is fixed (e.g., mussels) and/or restricted to a small area in close proximity to the point of discharge (within 100 m), mortality is unlikely. We wouldn't expect mortality of salmonids and other pelagic fish moving through the mixing zone, however, resident or sessile species could experience morality (Figure 3.3.11).

Chronic effects are developed using Life cycle, partial life cycle and early life stage tests all with extended exposure periods. Life cycle tests with fish last for at least 24 days and 90 days for salmonids after the hatching of the next generation. Life cycle tests with mysids continue until 7 days past the median time of first brood release in the controls. Partial life-cycle tests are allowed with fish species that require more than a year to reach sexual maturity, so that all major life stages can be exposed to the test material in less than 15 months. Early life-stage toxicity tests consist of 28- to 32-day (60 days post hatch for salmonids) exposures of the early life stages of a species of fish from shortly after fertilization through embryonic, larval, and early juvenile development (EPA 1985).

Given the exposure duration used to develop chronic effects levels it's apparent that although the concentrations resulting in chronic effects are present in the mixing zone, the duration of exposure necessary to experience those effects is unlikely except for sessile species or those with restricted ranges. Species with small home ranges (shrimp and prawns) or drifters (amphipods) are the most likely to be adversely affected. Juvenile fishes that remain in the nearshore or in estuaries to rear where mixing zones are allowed may be repeatedly exposed to pollutants prior to migrating out to sea. Salmonids and other adult pelagic fish would likely swim through the mixing zone and would not be exposed for a length of time that would cause them to experience chronic effects. Beluga whales feed on ground fish such as cod and sole. These ground fish are exposed in much the same way as other benthic species and depending on the extent of their home range could be exposed to the mixing zone for a longer period of time than pelagic fish species.

3.3.4 Evaluation of Principal Biological Features

As discussed earlier in the Approach to Effects Analysis section, EPA evaluated the effects of mixing zones for PBFs 1, 2 and 3 of Cook Inlet beluga whale designated critical habitat.

The area of Cook Inlet designated as critical habitat for beluga whales is 13,217 mi ^{2} (34,243 km ^{2}). Within this area there are approximately 45 facilities with mixing zones; they include, 25 oil and gas, 6 wastewater related (including municipal wastewater), and 14 seafood processing facilities. There are multiple mixing zones authorized for some of these facilities and some facilities (seafood processing vessels) are authorized to discharge into mixing zones at multiple locations. EPA estimated that the area authorized for mixing zones is 600 - 700 km ^{2}, or approximately 2 percent or less of total Cook Inlet beluga whale designated critical habitat.

3.3.4.1 PBF 1 *Intertidal and subtidal water of Cook Inlet with depths less than 9.1 m (30 ft) mean lower low water and within 5 miles (8 km) of high and medium flow anadromous fish streams* - In this supplemental analysis the evaluation of the impacts of mixing zones on PBF 1 was focused specifically on the physical effects on habitat. As presented in Table 3.3.3, the parameters considered relate to the characteristics of the discharge (e.g., flow and quality); the chemical characteristics of the pollutants identified in the permit; and, the physical habitat disturbance anticipated. In addition to the information on flow from the facility, we considered the hydrodynamics of the receiving water to determine what is known about currents and tides in Cook Inlet that may affect the potential for pollutant dilution and dispersion.

In order to focus on mixing zones that had the potential to affect PBF 1, EPA mapped the 30 ft depth contour, identified the anadromous fish streams using the Alaska Department of Fish and Game Anadromous Fish Resource Monitor (hereafter ADFG FRM) interactive mapping tool, and then identified which mixing zones in Cook Inlet were within five miles of anadromous fish streams (Figure 3.3.1). There are approximately 13,694 km^2 of designated critical habitat shoreward of the 30 ft depth contour (less than 9.1 m MLLW). Approximately 25 facilities with mixing zones are located within both the designated critical habitat and shoreward of the 30 ft depth contour. EPA estimated that the area authorized for mixing zones is approximately 260 km^2, or approximately 2 percent or less of the area within PBF 1.

Of the 37 major drainages in Cook Inlet associated with salmonid migration (anadromous fish streams), the Kenai and Kasilof Rivers and a number of creeks have facilities with mixing zones that discharge shoreward of the 30 ft depth contour within five miles of anadromous fish streams. We focused on both mixing zones for municipal wastewater and seafood waste discharges associated with the lower Kenia River. Mixing zones in this location were selected because of the importance of the Kenai River to spawning and rearing of beluga whale prey species, specifically anadromous salmonids.

The degree to which these mixing zones are affecting PBF 1 has to do in part with: 1) the amount of material discharged from the facilities, 2) the specific location of the mixing zones, 3) the velocity of the Kenai River resulting in the movement of material out in Cook Inlet, and 4) the hydrodynamics of Cook Inlet that influence mixing and dispersion. The following sections present a discussion on the potential impacts on PBF 1 from mixing zones authorized for seafood waste discharges in the Kenai River estuary and the municipal discharge in Cook Inlet at the mouth of the Kenai River.

3.3.4.1.1 Seafood Waste Mixing Zone - During discharge of seafood processing waste, biological impacts are most likely to occur as a result of the discharge of seafood waste particulates (both direct and indirect effects). The focus of this analysis is the mixing zone and not the ZOD. However, in addition to water column impacts, there are effects on the benthic habitat and community from particulate matter that settles within the mixing zones; these effects are discussed in the following sections.

The amount of material discharged by the four seafood processing plants in Lower Kenai River is presented in Table 3.3.2. The facilities discharge over 10 million pounds of fish waste in shallow water (-10 – 30 ft) and generally 100 ft from shore. These locations are important habitat for migrating salmonids and juvenile out- migrants (Figure 3.3.2).

In general, impacts of seafood processing wastes on receiving water quality and benthic habitat are inversely related to the assimilative properties of the receiving waters. In areas with strong currents and high tidal ranges, assimilation is high, waste materials disperse rapidly, and there is little impact on water quality. In areas of quieter waters, assimilation is lower, and waste materials can accumulate, resulting in solid waste piles, DO depressions, and associated aesthetic problems (EPA 1994).

The USGS has gaging stations in the upper river which have been recording flow for decades. According to the USGS stream flow data measured at gaging stations in the Kenai River near Soldotna, Sterling and the Copper River Landing, the flow in the Kenai River is substantial, at least up river (Table 3.3.6). The median flow at these locations ranges from 6800 cfs to over 13,000 cfs depending on the season (Table 3.3.6). It should be noted that these locations are well upriver from the seafood waste mixing zones where the river becomes and estuary (Kenai flats) and presumably velocity decreases; there are no USGS Gaging stations in the lower river. Although the velocity is expected to be lower; the lower river is also influenced by tidal flows, which would carry the material out into Cook Inlet, but may also transport it upriver during incoming tide potentially resulting in reflux of the seafood plumes if they are large enough and close enough to overlap under these conditions. At this point we have no specific information about the flow in the Kenai River estuary needed to predict the likelihood and level of dispersion of seafood waste.

Of the wastes associated with seafood processing discharges, numeric effluent limitations exist only for the annual amount discharged (10 million pounds), BOD and TSS. Potential adverse impacts on receiving water quality and benthic habitat resulting from seafood processing wastes include a reduction in water column DO due to the decay of particulate and soluble waste matter; the release of toxic levels of sulfide and ammonia from decaying waste, and nutrient enrichment. All of these biochemically-generated pollutants are likely to affect the biological communities present in the mixing zone and are discussed in the following sections.

Suspended solids – Once settled, particles can form organic mats that can smother the underlying substrate and benthic communities within the mixing zone (unless the hydrology permits a localized deposition). The accumulation of these deposits in some areas indicates that the rate of discharge exceeds the assimilation capacity of some water bodies and more specifically, the assimilation capacity of the benthic community and other aquatic life that metabolize this material. Many benthic invertebrates are relatively stationary and sensitive to environmental disturbance and pollutants.

Deposition of seafood waste particles is expected to smother biota in the area near the discharge, potentially reducing the abundance or eliminating entirely infauna such as polychaetes, mollusks, and crustaceans. Additionally, demersal eggs of various benthic species and fish may be smothered by settling solid waste.

Within the mixing zone, zooplankton and fish larvae, smolts and juvenile near the discharge may experience temporary effects including altered respiratory or feeding ability due to stress, or clogging of gills and feeding apparatus. Phytoplankton entrained in the discharge plume may have reduced productivity due to decreased light availability. These impacts are likely to occur in a limited area within the mixing zone in proximity to the point of discharge.

Liquid wastes - Liquid seafood processing discharges includes two waste streams, one directly associated with the seafood waste and the other associated with ancillary operations whose wastewaters do not come in contact with seafood waste. Liquid seafood processing wastes contain soluble materials that include soluble oxygen demanding substances (i.e., BOD), nutrients and oil and grease. These discharges may also contain disinfectants, including ammonia and chlorine which may produce direct toxic effects. Seafood processing discharges may contain residual concentrations of chlorine-based disinfectants. The toxicity of ammonia as UIA has been addressed in detail in this document, and the potential impacts to aquatic organisms within municipal WWTP mixing zones is presented. Because there are no WQBELs for these pollutants for seafood waste discharges, we are unable to determine exposure point concentrations needed to predict the likelihood of adverse effects on PBF 1 from their presence in the mixing zone. However, we anticipate that some level of ammonia generated from decaying matter and episodic use and discharge of chlorine are present and impacting aquatic organisms within the mixing zones.

DO and BOD - DO is a key element in water that is necessary to support aquatic life. It is depleted during the breakdown of "oxygen-demanding" substances such as organic matter and ammonia. These substances are usually destroyed or converted to other compounds by bacteria if there is sufficient oxygen present in the water; however, DO needed to sustain fish life may be consumed in this breakdown process.

DO depletion caused by decomposition of organic matter or nitrification of ammonia is often measured as BOD. BOD is a measure of the amount of oxygen consumed by the respiration of microorganisms while feeding on decomposing organic material. Organic seafood wastes can exert a large BOD in receiving waters. The impact of BOD on water quality is particularly influenced by the dispersive capacities of the receiving water. In areas of low flushing, BOD from seafood processing effluent may depress DO to unacceptable levels (Ahumada et al. 2004). Conversely, studies have found little impact of BOD in areas with highly dynamic water regimes (Gates et al. 1985). Unfortunately, EPA was unable to locate any hydrodynamic information for the Kenai River estuary, so we cannot make any definitive statements regarding the likelihood of DO depletion within these mixing zones.

In areas of high BOD loads and low flushing, it is possible to reach conditions where DO in the water is totally exhausted, resulting in anaerobic conditions and the production of undesirable gases such as hydrogen sulfide and methane (Ahumada et al. 2004). Water with high BOD also has the potential for increased bacterial concentrations that degrade water quality (EPA 2005). High BOD loads coupled with low dispersive capability may cause low DO concentrations or the complete absence of DO, which can be lethal to marine organisms. It's unlikely that a waterbody as large as the Kenai River estuary would become anaerobic. However, there may be localized areas of anaerobic sediments within the mixing zone due to the breakdown of waste material that is not transported out of the immediate area.

Excessive nutrients - Excessive nutrients can cause a multitude of problems in coastal areas including eutrophication, harmful algal blooms, fish kills, shellfish poisonings, loss of seagrass and kelp beds, coral reef destruction, and reduced DO. As stated above, nitrogen is a common pollutant found in seafood processing waste. Nitrogen is known to be particularly damaging to bays and coastal seas by boosting primary production (the production of algae). With excessive amounts of nitrogen, algae growth and increasing denitrifying bacteria make the water more turbid.

As the algae die and decompose, DO can be depleted if there is insufficient mixing or a lack of other re-aeration mechanisms present (Howarth et al., 2000; Novatec, 1994). High levels of living algae can also lead to depletions in oxygen over the nighttime hours due to their oxygen consumption. Low DO levels can cause direct mortality of organisms, or reduced efficiency of physiological processes (e.g. food processing, growth).

These changes in nutrients, light, and oxygen, favor some species over others causing shifts in phytoplankton, zooplankton, and benthic communities (Howarth et al. 2000). Unlike solid residues, nutrients are water soluble and can therefore be transported beyond areas of heavy deposition unless assimilated by aquatic life, sorbed to sediments, or released to the atmosphere (denitrification and volatilization of nitrogen).

3.3.4.1.2 Municipal Wastewater Mixing Zone - During negative low tides the discharge pipe for the Kenai WWTP is exposed and dilution of the effluent doesn't occur until the effluent reaches the water. The APDES permit states that the during these negative low tides the mixing zone area is the half circle of the radius of the acute (7 m) and chronic (150 m) mixing zones, respectively. Within these exposed areas the pollutants in the effluent are discharged directly onto the sediments. Those hydrophobic or ionic pollutants within the discharge will adhere to ionizable functional groups within organic matter in the sediments. These conditions may result in increasing pollutant concentrations and increased bioaccumulation of pollutantsin the aquatic food web. Given that the average monthly flow of the WWTP is 0.54 mgd and the end of the outfall is exposed for 2 hours during each 12 hour tidal cycle for 14% of the yearly tidal cycles, then 4.1 mg/yr of effluent are discharged directly onto the sediments.

EPA has not been able to locate sediment data for the exposed area that receives the discharge during negative tides, so it's not possible to characterize the chemical composition or quantify the pollutant concentrations. Consequently, it's not possible to describe the level of adverse effects that are potentially occurring to the benthic and epibenthic community, and therefore designated critical habitat. However, it is likely that some level of adverse effects are occurring given that millions of gallons of wastewater are discharged directly onto sediment on a regular basis.

3.3.4.2 Effects of the Action on PBF 2: ***Primary prey species consisting of four species of Pacific salmon (Chinook, sockeye, chum, and coho), Pacific eulachon, Pacific cod, walleye pollock, saffron cod, and yellowfin sole*** **-** When reviewing the literature on beluga whale prey species some key locations stand out. In Upper Cook Inlet these locations are the major rivers including the Susitna, Twenty Mile, and Chuitna, and in lower Cook Inlet they are the Kasilof, Kenai, and the area around Kalgin Island.

Both research and empirical data suggest that Beluga whale access to prey within critical habitat occurs primarily in upper Cook Inlet and at the mouths of these large river systems. However, there are no mixing zones in the vicinity of the river systems in upper Cook Inlet. Therefore, the focus of this analysis is on pollutants in mixing zones from Kenai WWTP and seafood discharges in the Kenai River estuary.

The analysis for PBF 2 consists of a toxicity assessment for pollutants with WQBELs and the primary prey (or representative surrogates) of the Cook Inlet beluga whale for the same mixing zones listed in PBF 1 (Table 3.3.3). These mixing zones are in the vicinity of prey migration and use areas, and in the nearshore where juveniles would also be found.

The Kenai River estuary supports high species diversity, with species abundance dependent on season and habitat, and is an important migration route for juvenile Chinook, sockeye and pink salmon that spawn and rear in tributaries in the lower Kenai River. In 2003, 31 taxonomic groups of fishes and macroinvertebrates were found in this area (Willette et al. 2004):

- Epibenthic invertebrates (*Crangon spp.*, *Neomysis spp.*, and *Saduria spp.*)
- finfish
    - Pacific eulachon (*Thaleichthys pacificus*),
    - juvenile sockeye (*Oncorhynchus nerka*), Coho (*O. Kisutch*), and Chinook salmon (O. *tshawytscha*),

- Pacific staghorn sculpin (*Leptocottus armatus*),
- snake prickleback (*Lumpenus sagitta*), and
- starry flounder (*Platichthys stellatus*),
- Pacific herring (*Clupea pallasii*),
- Pacific sandfish (*Trichodon trichodon*)

Of the species listed above the Pacific eulachon and the salmonids are considered primary prey that utilize the Kenai River. Other primary prey species Pacific cod (*Gadus macrocephalus*), walleye pollock (*G. chalcogrammus*), saffron cod (*Eleginus gracilis*), and yellowfin sole (*Limanda aspera*) are found in Cook Inlet and may be exposed to pollutants within the Kenai WWTP mixing zone. The primary prey species were the focus on the analysis of PBF 2.

This analysis tiers off the information included under PBF 1 where we presented what is known about the permits being considered, the hydrodynamics of the receiving waters and the physical and chemical characteristics of the discharges. This next section incorporates what's known about beluga whale primary prey species which would increase their exposure to the effluents in the mixing zones, and the toxicity of the pollutants for which the mixing zones were assigned.

3.3.4.2.1 Seafood Waste Mixing Zone – As described under PBF 1 there are four seafood facilities with 100 ft (radius) mixing zones approximately 1,000 ft apart in the lower Kenai River (Figures 3.3.1 and 3.3.2). These mixing zones are in shallow (-5 to -30 ft) water within 150 ft of the shoreline (Table 3.3.1). The physical and chemical characteristics of seafood waste considered stressors are described in detail above and presented in Tables 3.3.2 and 3.3.3. We did not repeat that information in this section, instead we describe the likelihood that beluga whale prey species may be exposed to these stressors to determine the likelihood that seafood waste mixing zones are adversely affecting PBF 2.

In addition to designated critical habitat for the Cook Inlet Beluga whale, the Kenai River estuary is essential fish habitat for Coho, Chinook, pink and sockeye salmon and Pacific eulachon; all primary prey species of the beluga whale. The previous consultation on approval of the mixing zone rule included an Essential Fish Habitat consultation under the Magnuson-Stevens Fishery Conservation and Management Act, as amended by the Sustainable Fisheries Act of 1996 (Public Law 104-267). That essential fish habitat analysis (portions of which are presented below) covered the Cook Inlet beluga whale primary prey species identified in this PBF for the entire state of Alaska including Cook Inlet.

3.3.4.2.1.1 Coho - Coho salmon spawn in small streams. They are typically the last salmon to arrive at the spawning areas, generally from July to December (NMFS 2005). Eggs are laid in stream gravels and after one to 3 years in fresh water ponds, lakes, and stream pools, the salmon smolts move downstream to the open ocean. Some coho salmon may use estuarine areas in the summer of their first year in the ocean, but migrate upstream to overwinter in freshwater (NMFS 2005). According to the ADFG FRM, Coho rear in tributaries to the lower Kenai River upstream of the seafood processing mixing zones and must pass these zones on their outward migration to the marine waters of Cook Inlet (Figure 3.3.2). Therefore, Coho smolts must pass by or through the mixing zones during their downstream migration, and some may remain in the estuaries during their first year perhaps undergoing repeated exposure to the mixing zones either traveling through or being attracted by the consistent food source.

3.3.4.2.1.2 Chinook - Chinook salmon spawn in small and large streams, adults return to streams at age 2 to 7 years. Two forms (ocean type and stream type) of juvenile freshwater rearing life history are present for Chinook salmon. Juveniles that emerge and migrate to the ocean within weeks or a few months are called "ocean type", and have extensive estuary rearing. Those juveniles that rear in freshwater for typically 1 to 3 years before migrating to the ocean in the spring are called "stream type," and spend less time in estuarine waters. Stream type Chinook salmon are dominant in Alaska. Chinook salmon tend to stay deeper in the water column than other salmon, typically deeper than 30 meters, while other species tend to stay in the upper 20 meters (NMFS 2005). According to the AGFG FRM, Chinook spawn in the Kenai River and rear in tributaries to the lower river upstream and downstream of the seafood processing mixing zones. Those juveniles that rear upstream must pass by or through these mixing zones on their outward migration to Cook Inlet.

3.3.4.2.1.3 Pink Salmon- According to the ADFG FRM, pink salmon spawn in the Kenai River. Pink salmon spawn in small streams within a few miles of the shore, or within the intertidal zone, or at the mouths of streams. Salmon fry move downstream to the open ocean after hatching. Pink salmon stay close to the shore moving along beaches during their first summer feeding on plankton, insects and small fish. At about 1 year of age, pink salmon move offshore to ocean feeding. Out migrants stay close to shore and depending on depth may encounter the 100 ft mixing zones, which are also close to shore (40 ft to 150 ft); therefore, exposure to the seafood waste is possible for some unknown period.

3.3.4.2.1.4 Sockeye Salmon - Sockeye salmon spawn in stream systems with lakes, or on lake-shoreline areas, during late summer or fall. According to the ADFG FRM sockeye spawn in Skilak and Hidden Lakes which feed into the Kenai River. Adfluvial populations may spend one to three years in fresh water before fry move downstream through the Kenai River to Cook Inlet. According to the ADFG FRM, sockeye also rear in tributaries in the lower Kenai River up and downstream of the seafood waste mixing zones, but there is no indication that they rear in the mainstem Kenai River. As with other juvenile salmonids, individuals are likely exposed to mixing zones during out-migration to Cook Inlet. Out migrants stay close to shore and likely encounter the 100 ft mixing zones which are also close to shore (40 ft to 150 ft), therefore exposure to the seafood waste is likely for some unknown period.

3.3.4.2.1.5 Pacific Eulachon - Forage fish, as a group, occupy a central position in the North Pacific Ocean food web, being consumed by a wide variety of fish, marine mammals, and seabirds. The complex includes many species, but the most common are capelin (*Mallotus villosus*), Pacific eulachon, Pacific sand lance (*Ammodytes hexapterus*), and Pacific herring. According to the species profile compiled by the NMFS[4], Pacific eulachon typically spend 3 to 5 years in marine waters before returning to freshwater to spawn from late winter through mid- spring. Most Pacific eulachon adults die after spawning. Pacific eulachon eggs hatch in 20 to 40 days. The larvae are then carried downstream and are dispersed by estuarine and ocean currents shortly after hatching. Juvenile Pacific eulachon move from shallow nearshore areas to mid-depth areas. According to ADFG FRM, Pacific eulachon neither spawn nor rear in the Kenai River but are present presumably as adults. It is likely that adults may encounter the mixing zones briefly unless they are attracted by particulates in the waste stream.

3.3.4.2.1.6 Summary – The Kenai River is one of the major rivers in Cook Inlet known to support significant populations of salmon. The River has been documented as supporting spawning and rearing of these species. Therefore it's very likely that migrating adult salmon and Pacific eulachon will be exposed to pollutants within the seafood waste mixing zones as they move in and through the lower river. It's also likely that juvenile salmonids are exposed to some unknown concentrations of pollutants

[4] http://www.fisheries.noaa.gov/pr/species/fish/eulachon.html accessed 7/11/2016

in the mixing zones while moving along the shoreline in the lower Kenai River. These fish will likely encounter reduced water quality and prey availability and degraded benthic habitat in localized areas.

As previously discussed, seafood processing discharges includes two waste streams, one directly associated with the seafood waste and the other associated with ancillary operations whose wastewaters do not come in contact with seafood waste. Liquid seafood processing wastes contain soluble materials that include soluble oxygen demanding substances (i.e., BOD), nutrients and oil and grease. These discharges may also contain disinfectants, including ammonia and chlorine which may produce direct toxic effects. In fish, gills are believed to be the primary site of toxic action of chlorine and ammonia. This is based on multiple observations of damage to gill epithelium following exposure to these pollutants chlorine. Cairns et al. (1975) concluded that the mode of toxic action of chlorine to fish is gill tissue damage combined with accumulation of mucus on the gills. Elevated concentrations of FOG in the mixing zone likely exacerbate the impact of these chemical stressors on gill tissues and respiration. While UIA caused gill hyperplasia, decreasing the surface area of the gills and reducing respiratory function. The combination of physical damage to gill tissue and coating of gill tissue by mucus inhibits oxygen uptake, resulting in suffocation of the fish. In addition, damage to gills increases the likelihood of infections which also reduces fitness.

As also previously discussed, the flow in the upper Kenai River is substantial according to data collected by the USGS gaging stations (Table 3.3.6). The median flow at these locations ranges from 6800 cfs to almost 13,000 cfs depending on the season and location. We have no information on the concentration of pollutants in the mixing zones or the dispersion of seafood waste except to say that the Kenai River is not included on Alaska's list of impaired waters, and therefore water quality has not been identified as limiting to beneficial uses including fish and wildlife.

The degree to which adverse effects to fish may be occurring has to do with the extent of exposure to areas within the water column with elevated TSS, BOD and reduced DO. Juveniles of species that rear in the lower river and non-spawning adults that are present in the lower river are more likely to have longer and/or repeated exposures to pollutants in the mixing zones.

3.3.4.2.2 Municipal Wastewater Mixing Zone – Ammonia - EPA demonstrated through the moving weighted averaging approach that a low level of mortality is likely when species are in close proximity to the point of discharge (Figure 3.3.10). The species for which we have toxicity data include flatfish (winter flounder), pelagic fish, crustaceans (prawns and shrimp) and drifters (amphipods and copepods). However, the focus of this PBF is on the primary prey species, which only includes fish.

There were no toxicity tests with ammonia conducted on the primary prey species that we could use in the toxicity assessment and plot on the SSDs. Therefore, we used EPA's Web-ICE program to attempt to predict LC_{50}s for prey species based on surrogates. We developed an LC_{50} for the Coho using EPAs WEB-Ice program and the yellow perch (*Perca flavescens*) as a surrogate (Figure 3.3.12) and then calculated the LC_{Low}. The LC_{Low} for Coho and presumably other *Oncorhynchus* falls between the 20 m boundary and the point of discharge, meaning the fish would have to remain in close proximity to the discharge pipe in order to experience mortality (the concentration of UIA at the point of discharge is 1.2 mg/L) (Figure 3.3.10).

Sensitive saltwater organisms appear to have a narrow range of acute susceptibilities to ammonia. When comparing the LC_{Low} concentrations for the species plotted on the SSD with the moving weighted average UIA concentrations we've estimated that greater than 29 percent of the species that remain in the mixing zone in close proximity to the point of discharge (< 60 m) will experience mortality (Figure 3.3.11). This includes fish species particularly the winter flounder which could represent other demersal beluga whale prey such as the yellowfin sole. Coho salmon, and potentially other adult salmonids, would not be expected to experience mortality based on the LC_{Low} predicted using EPA's Web-ICE, unless they were to remain within 20 meters of the discharge pipe (Figures 3.3.12 and 3.3.14).

Comparing the FCVs for all fish species tested, Figures 3.3.13 and 3.3.14, shows these species would experience chronic effects, as the UIA concentrations at all predicted distances from the point of discharge are greater than the FCVs. Therefore, those species that remain in the mixing zone may experience chronic effects on growth, reproduction or development depending on the exposure duration.

It's unlikely that adult pelagic fish are experiencing acute or chronic effects from exposure to UIA in the mixing zone due to their mobility. Pelagic fish are an important component in the beluga whale prey base, however demersal fish species are also important. Depending on the home range and migratory behavior of these demersal species, there is a possibility that they may be exposed to the mixing zone for longer periods than pelagic species and experience chronic effects. Demersal species also have a closer association with the sediments and pollutants that have partitioned out of the mixing zone, or have been discharged directly onto the sediments, in the case of the Kenai WWTP.

3.3.4.3 Effects of the Action on PBF 3: *Waters free of toxins or other agents of a type and amount harmful to Cook Inlet Beluga Whale* - The impact on water quality is a direct effect of the proposed action and the previous consultations on this action included an analysis of the direct effects of water quality on the Cook Inlet beluga whale (EPA 2009a; NMFS 2010). In evaluating PBF 1, EPA considered the effects of the proposed action on habitat, and in evaluating PBF2 we focused on the effects on primary prey. In order to address PBF 3, EPA focused on the indirect effects on the Cook Inlet Beluga whale through an analysis of the greater (lower trophic level species) aquatic food web.

EPA has discussed at length the acute and chronic effects of pollutants discharged in mixing zones on the primary prey and habitat, including species that make up the aquatic food web (PBF 1 and 2 and in Section3.3.3.5). EPA identified the likelihood of acute and chronic effects to primary prey of the beluga whale and lower trophic levels species that are representative of the aquatic food web in Cook Inlet.

The following sections summarize the information previously presented and focus specifically on lower trophic level species.

3.3.4.3.1 Seafood Waste Mixing Zone – Potential adverse impacts on receiving water quality resulting from seafood processing wastes include reduction in water column DO due to the decay of particulate and soluble waste matter; the release of toxic levels of sulfide and ammonia from decaying waste; nutrient enrichment and stimulation of phytoplankton growth and alteration of the phytoplankton community. All of these water quality impacts are likely to affect the organisms present in the mixing zone including phytoplankton and zooplankton and benthic species, which are important components of the aquatic food web.

In 2009, EPA prepared a BE for the General NPDES Permit for Offshore Seafood Processors in Alaska (EPA 2009b.). In that document we presented a description and results of a study initiated by ADEC to evaluate the impacts of discharge of seafood waste. One component of this research was to evaluate seafood solid waste impacts on the benthos (Germano and Associates, 2004).

The intent of this study was to determine the impacts to the surrounding benthos and benthic community from seafood solid wastes deposited in a ZOD. We note that the proposed action of this consultation does not include an evaluation of the ZOD, however the results of this study are germane to the impacts from the material that may partition out of the mixing zone onto the benthos. In the Germano and associates study (2004) the impacts were evaluated using a Sediment Profile Imaging (SPI) camera. The SPI camera takes an image of the top few inches of sediment. Aquatic life within the sediments was also collected for analysis using a Van Veen grab device. The SPI camera showed where seafood wastes made the sediments anoxic and methane producing with the presence of sulfur-producing bacteria, Beggiatoa, indicating anoxic conditions.

For two adjacent processors with relatively small, active discharges located approximately 600 feet apart, the visual ZOD were 0.34 and 0.21 acres. However, the area of Beggiatoa was approximately 6.0 to 7.4 acres. The presence of Beggiatoa indicates reduced oxygen in the sediments and an adverse effect to the benthos and benthic community outside of the ZOD. Other measures for adverse effects include numbers and kinds of species present.

Immediately adjacent to the smaller active piles are where both fish and crab forage. The diversity of benthic species was less within the first 200 feet of the periphery of the ZOD compared to the diversity observed in a distant control site. However, the few opportunistic species that existed in the vicinity of the ZOD occurred in great numbers. At approximately 500 feet or more from the periphery of the active piles more of the normal resident species were recorded and the overall abundance of the opportunistic species was less. The study determined that normal resident species population levels and diversity did not occur until 1,500 feet or more down-current of the periphery of the waste piles.

Two other seafood processors evaluated had larger discharges and inactive waste piles greater than 1 acre in size. Very little to no solid waste discharges had occurred for the 2 years preceding the study. These discharges occurred approximately 1,000 feet apart. In this case, the Beggiatoa were observed in 2.8 and 0.5 acres around each waste pile respectively. The areas of reduced oxygen due to Beggiatoa were significantly smaller for the inactive waste piles than for the active waste piles. From these results, the authors of the study conclude that biota in sediments may revert to natural conditions within 5-10 years after the cessation of seafood waste disposal (Germano and Associates, 2004).

The four seafood waste mixing zones in the Kenai estuary are approximately 1,000 ft apart, similar to the situation described in the study. Depending on the depth of burial, deposits can make the substrate inhospitable, or influence the species composition favoring opportunistic organisms that may out-compete the normal fauna affecting the natural community composition and food web. It's possible that the mixing zones in the Kenai River estuary may be causing a similar level and type of effect as documented by Germano et al. (2004) if the material is not transported out of the lower river into Cook Inlet. If transport isn't occurring it's very likely that a buildup of seafood waste within the four mixing zones is adversely affecting the benthic community, through degradation of approximately 3.0 acres of critical habitat in the Kenai River estuary.

Many benthic invertebrates are relatively sedentary and sensitive to environmental disturbance and pollutants. Short- and long-term effects of seafood waste on benthic invertebrates are expected to include temporary smothering of biota, especially by ground particulates in the area near the discharge. Deposition could potentially reduce and possibly eliminate abundances of infaunal benthos such as polychaetes, mollusks, and crustaceans, and may affect demersal eggs of various benthic species and fish.

3.3.4.3.2 Municipal Waste Mixing Zone – Ammonia – EPA demonstrated through the moving weighted averaging approach (Section 3.3.3.2) that a low level of mortality is likely when species are in close proximity to the point of discharge (Figures 3.3.10 and 3.3.11). The species tested include both fish (considered primary prey) and invertebrates, however, the focus of this PBF is on the lower trophic organisms that are not considered primary prey species.

Sensitive saltwater organisms appear to have a narrow range of acute susceptibilities to ammonia. When comparing the LC_{Low} concentrations for the species plotted on the SSD with the moving weighted average UIA concentrations we demonstrated that shrimp, amphipods and copepods are likely to experience some level of mortality when exposed to UIA within approximately 70 m from the point of discharge (Figures 3.3.11 and 3.3.15). When comparing the FCVs for all invertebrates' species tested Figure 3.3.15 shows these species would experience chronic effects, as the predicted UIA concentrations at all distances from the point of discharge are greater than the FCVs. For sessile or stationary species or species that have repeated exposure chronic exposure is likely.

EPA anticipates that species with small home ranges (shrimp and prawns) or drifters (amphipods) are likely to experience acute and chronic effects depending on their location within the mixing zone and duration of exposure. Additionally, benthic and sessile species are likely to experience acute and chronic effects when wastewater is discharged directly on the substrate during periods of low tides.

3.3.5 Literature Cited

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Tables for Section 3.3

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Table 3.3.1 - General Information for Mixing Zones that may be affecting physical and biological features of designated critical habitat.

Water Body	Permit	Design and Mean			Average Monthly/Maximum Daily (mg/L)		Mixing Zone Size	Level of Treatment
		Monthly Flow (mgd)	BOD	TSS lbs/day	Total Residual Chlorine	Ammonia as N		
Cook Inlet	Asplund WWTP AK0022551	58/33.7	240/250/300 mg/L 72,100/75,100/90, 100 lbs/day (mean monthly/weekly/daily)	170/180/190 mg/L 51,000/54,000, 57,000 lbs/day (mean monthly/weekly/daily)	1.2 mg/L (maximum daily)	No effluent limit	Circle with a radius of 2130 ft = 1.33 km^2 328 acres	Primary
Kenai River	City of Kenai WWTP AK0021377	1.3/0.54	2097/1140 (5-day lbs/day)	1980/1111	0.0075/0.013	14/29	Circle with a radius of 150 ft pipe not exposed: 0.07 Km^2 ;17.5 acres pipe exposed: 0.035 km^2 ; 8.75 acres	Secondary
	Permit	**Species Processed**	**Daily Solids Discharged (lbs)**	**Annual Solids Discharged (lbs)**	**Distance from Shore at MLLW (ft)**	**Depth of outfall and or Discharge (ft)**	**Allowable Mixing zone Size**	
	Great Pacific Seafoods AKG520479	Sockeye	10,000	200,000	30	Not reported in NOI	100 ft radius cylindrical	
		Pink	10,000	100,000				
	North Pacific Seafoods AKG520480	Salmon	30,000	2,200,000	100	-5 to -30	100 ft radius cylindrical	
	Pacific Star Seafoods AKG520478	Salmon	195,000	3,640,000	40	-10 to -30	100 ft radius cylindrical	
		Halibut	18,000	60,000				
		Sablefish	55,500	185,000				
		Pacific cod	48,000	480,000				
		Herring	4,000	40,000				
	Pacific Star Seafoods AKG520481	Salmon	50,000	1,500,000	100	-12	100 ft radius cylindrical	
		Halibut	15,000	500,000				
		Sablefish	37,000	250,000				
	Snug Harbor Seafoods AKG520483	Sablefish	10,000	40,000	150	-10	100 ft radius cylindrical	
		Pacific Cod & Rockfish	1,000	5,000				
		Halibut	10,000	150,000				
		Salmon	60,000	1,000,000				
Kasilof River	Kasilof River Plant AKG520487	Salmon	125,000	5,000,000	100	10 to 15	100 ft radius cylindrical	

Table 3.3.2 - The Total Daily and Annual Discharge of Seafood Waste in the Kenai River Estuary.

Permitted Daily Discharge (lbs)							
Permit Number	Sockeye	Pink	Salmon	Sablefish	Cod	Halibut	Herring
AKG520478			195,000	55,500	48,000	18,000	40,000
AKG520479	10,000	10,000					
AKG520480			30,000				
AKG520481			50,000	37,000		1,500	
AKG520483			60,000	10,000	1000	10,000	
Totals	10,000	10,000	305,000	102,500	49,000	43,000	40,000
Grand Total	**559,500**						
Annual Discharge (lbs)							
	Sockeye	Pink	Salmon	Sablefish	Cod	Halibut	Herring
AKG520478			3,640,000	185,000	480,000	60,000	40,000
AKG520479	200,000	100,000					
AKG520480			2,200,000				
AKG520481			1,500,000	250,000		500,000	
AKG520483			1,000,000	40,000	5,000	150,000	
Totals	200,000	100,000	8,340,000	475,000	485,000	710,000	40,000
Grand Total	**10,350,000**						

Table 3.3.3 - General Information for Mixing Zones that may be affecting physical and biological features of designated critical habitat.

Permit	Design and Mean			Average Monthly/Maximum Daily (mg/L)		Mixing Zone Size
	Monthly Flow (mgd)	BOD	TSS lbs/day	Total Residual Chlorine	Ammonia as N	
City of Kenai WWTP AK0021377	1.3/0.54	2097/1140 (5-day lbs/day)	1980/1111	0.0075/0.013	34/38	Circle with a radius of 150 m pipe not exposed: 0.07 Km^2; 17.5 acres pipe exposed: 0.035 km^2; 8.75 acres
Permit	**Species Processed**	**Daily Solids Discharged (lbs)**	**Annual Solids Discharged (lbs)**	**Distance from Shore at MLLW (ft)**	**Depth of outfall and or Discharge (ft)**	**Allowable Mixing zone Size**
Great Pacific Seafoods AKG520479	Sockeye	10,000	200,000	30	Not reported in NOI	100ft radius cylindrical
	Pink	10,000	100,000			
North Pacific Seafoods AKG520480	Salmon	30,000	2,200,000	100	-5 to -30	100 ft radius cylindrical
Pacific Star Seafoods AKG520478	Salmon	195,000	3,640,000	40	-10 to -30	100 ft radius cylindrical
	Halibut	18,000	60,000			
	Sablefish	55,500	185,000			
	Pacific cod	48,000	480,000			
	Herring	4,000	40,000			
Pacific Star Seafoods AKG520481	Salmon	50,000	1,500,000	100	-12	100 ft radius cylindrical
	Halibut	15,000	500,000			
	Sablefish	37,000	250,000			
Snug Harbor Seafoods AKG520483	Sablefish	10,000	40,000	150	-10	100 ft radius cylindrical
	Pacific Cod & Rockfish	1,000	5,000			
	Halibut	10,000	150,000			
	Salmon	60,000	1,000,000			

Table 3.3.4 - Allowable Discharge of Ammonia and Copper from the Kenai WWTP as reported in the Permit Fact Sheet.

Measurement (lbs)	Maximum		Average	
	Ammonia	Copper	Ammonia	Copper
Average monthly	152.0	195.0	152.0	195.0
Average weekly	288.0	293.0	288.0	293.0
Maximum daily	314.0	390.0	314.0	390.0
Hourly	13.1	16.3	1.7	0.1
12 hour	157.0	195.0	20.6	1.2
Yearly based on 14 %	16045.4	19929.0	255.4	327.6
Parameter	Effluent Limits			
	Minimum Daily	**Mean Monthly**	**Mean Weekly**	**Maximum Daily**
Total Residual Chlorine (mg/L)		0.0075		0.013
Total Ammonia as N (mg/L)[a]		34	38	38
Copper (total recoverable) µg/L		18	27	36

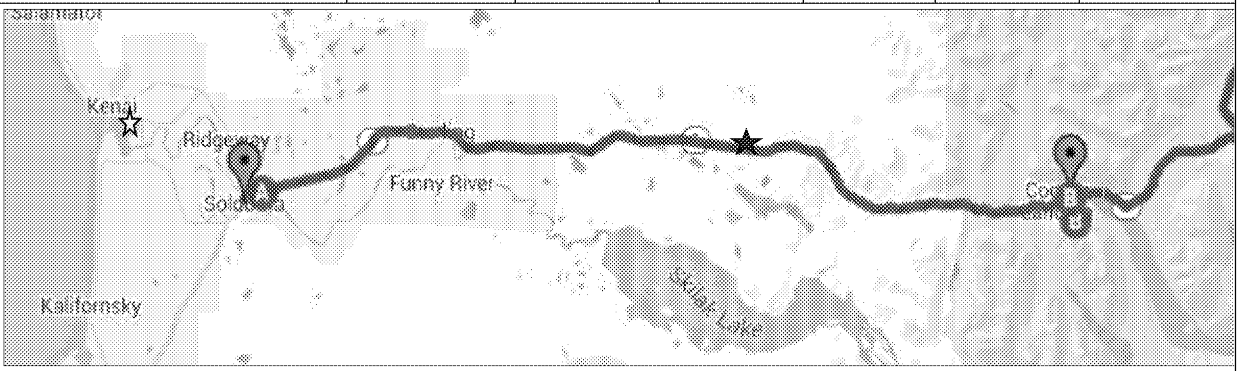
[a]: these are Interim ammonia limits associated with a compliance schedule until 2025.

Table 3.3.5 - Toxicity Test Report in the 304(a) Aquatic Life Criteria Document for Saltwater Ammonia in Addition to Data Collected after the Promulgation of the Ammonia Criteria in 1989.

Species Common Name	Species Scientific Name	SMAV (mg/L)	LC_{Low} (mg/L)	Final Chronic Value (mg/L)	Rank	Percent
Eastern oyster	*Crassostrea virginica*	19.10	9.55	1.458	25	100.0
Quahog Clam	*Mercenaria mercenaria*	5.36	2.68	0.409	24	95.8
Scud		3.35	1.68	0.256	23	91.6
Brackish water clam	*Rangia cuneata*	3.06	1.53	0.234	22	87.5
Three-spined stickleback	*Gasterosteus aculeatus*	2.93	1.47	0.224	21	83.3
sheepshead minnow	*Cyprinidon variegatus*	2.74	1.37	0.209	20	79.1
Amphipod		2.49	1.25	0.190	19	75.0
American Lobster	*Homarus americanus*	2.21	1.11	0.169	18	70.8
White Perch	*Morone americana*	2.13	1.07	0.163	17	66.6
Grass shrimp	*Palaemonetes pugio*	1.65	0.83	0.126	16	62.5
Amphipod		**1.59**	0.80	0.121	15	58.3
Striped mullet	*Mugul cephalus*	1.54	0.77	0.118	14	54.1
Coho Salmon	*Oncorhynchus kisutch*	1.30	0.65	0.099	13	50.0
Inland silverside	*Menidia beryllina*	1.12	0.56	0.085	12	45.8
Spot	*Leiostomus xanthurus*	1.04	0.52	0.079	11	41.6
Striped bass	*Morone saxatilis*	1.03	0.52	0.079	10	37.5
Mysid	*Mysidopsis bahia*	1.02	0.51	0.078	9	33.3
Copepod		0.87	0.43	0.066	8	29.1
Amphipod		0.83	0.42	0.063	7	25.0
Planehead filefish	*Monocanthis hispidus*	0.83	0.41	0.063	6	20.8
Copepod		0.79	0.40	0.060	5	16.6
Prawn	*Macrobrachius rosenbergii*	0.78	0.39	0.059	4	12.5
Sargassum shrimp	*Latreutes fucorum*	0.77	0.39	0.059	3	8.3
Reddrum	*Sciaenops ocellatus*	0.55	0.27	0.042	2	4.1
Winter flounder	*Pseudopleuronectes americanus*	0.49	0.25	0.038	1	0.0

Table 3.3.6 - Daily discharge statistics in cubic feet per second for the Kenai River from USGS based on over 19 years of record.

Station	Minimum	25th %ile	Median	Mean	75th %ile	Maximum
Soldotna (A)	8,650	11,500	12,700	12,800	14,100	17,800
Sterling ★	9,060	10,500	11,700	12,000	13,200	15,900
Cooper River Landing (B)	3,940	6,070	6,860	6,960	7,630	10,400



Figures for Section 3.3

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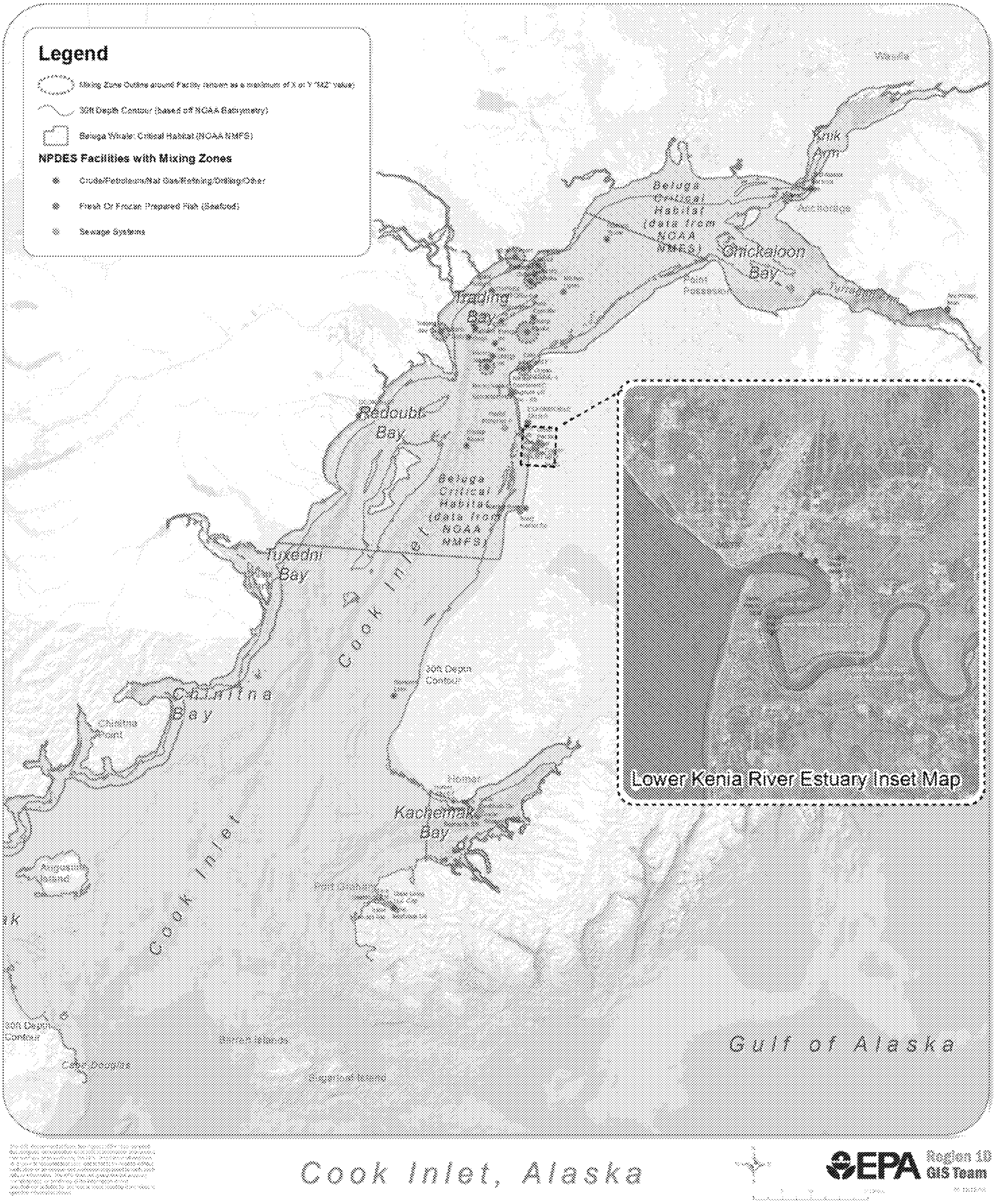

Figure 3.3.1 – Point Source Discharges with Mixing Zones Cook Inlet.

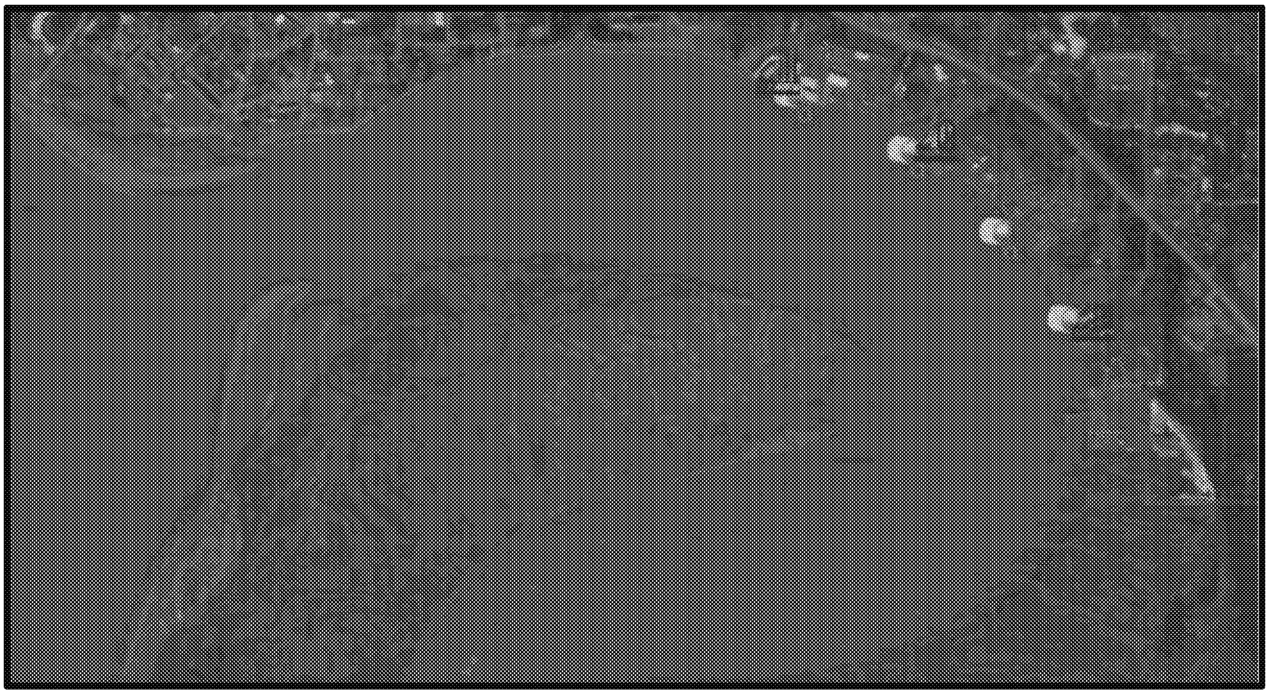

Figure 3.3.2 - Seafood Processing Discharges within the Kenai River Estuary.

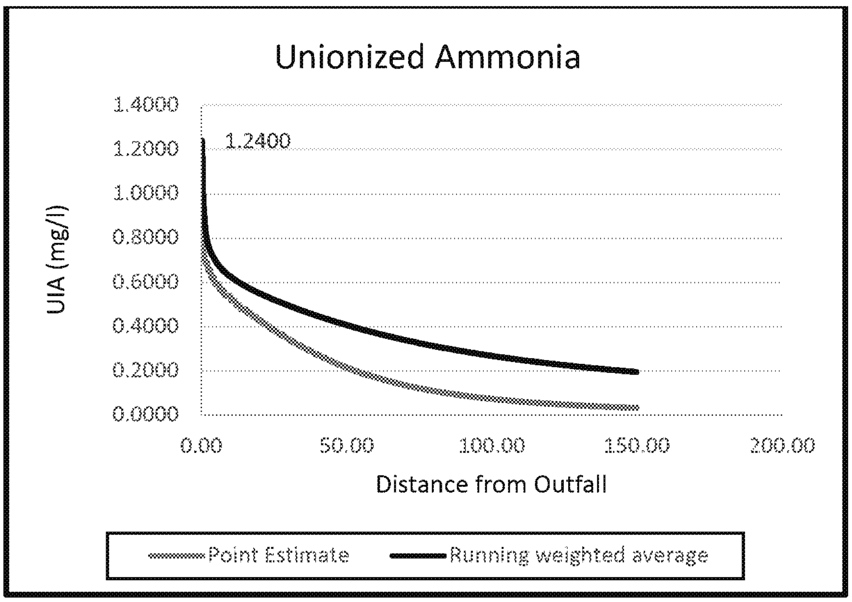

Figure 3.3.3 - Concentration of Un-Ionized Ammonia (UIA) throughout the Mixing Zone.

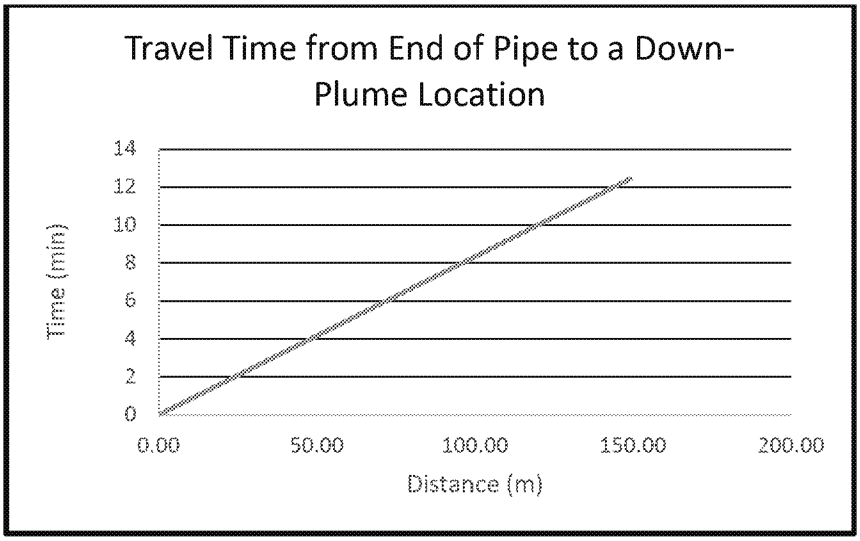

Figure 3.3.4 - Travel Time of from the Point of Discharge to the Edge of the Chronic Mixing Zone.

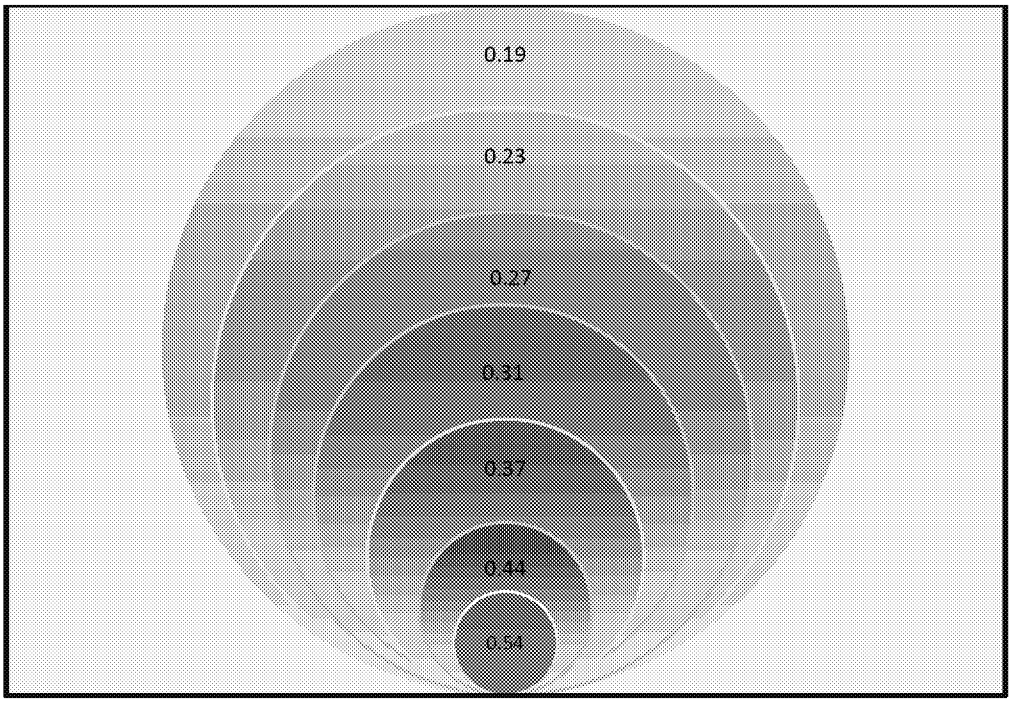

Figure 3.3.5 - The Un-Ionized Ammonia Concentrations (mg/L) at 20m Distance Increments from the Point of discharge to the Edge of the Chronic Mixing Zone. Note: last increment (0.19 mg/L) is at the edge of the mixing zone 150 m.

Unionized Ammonia Calculator v1.2;
after original by Dr. Landon Ross
Florida Department of Environmental Protection

Enter values into yellow cells

pH (SU)	8.2
Temperature (°C)	11
Salinity (ppt)	20
Total ammonia (mg/L as N)	38

Unionized Ammonia (mg/L as NH3)	**1.238985**

Figure 3.3.6 - Calculator Used to Convert Total Ammonia to Un-Ionized Ammonia Developed by the Florida Department of Environmental Protection.

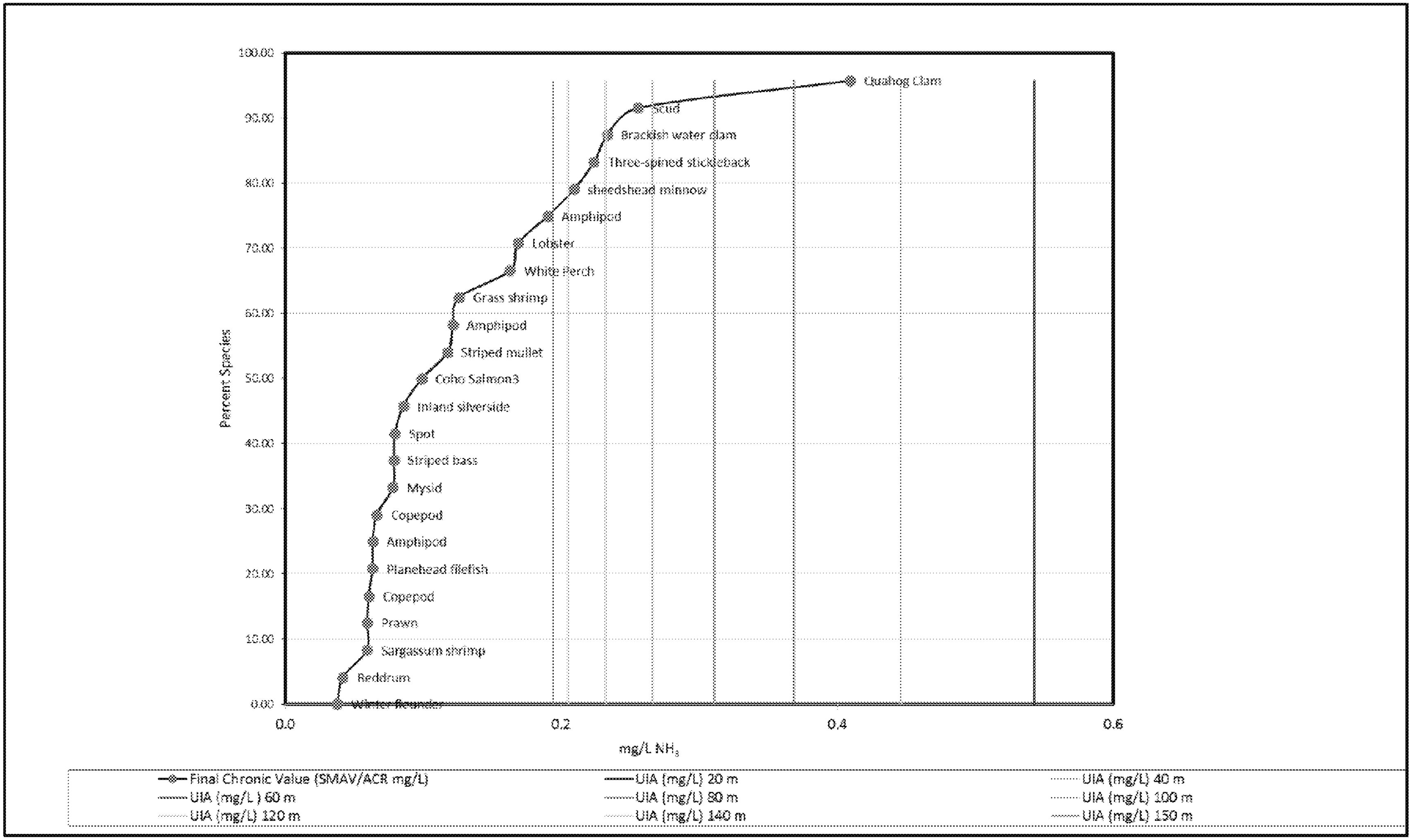

Figure 3.3.7 - Species Sensitivity Distribution for Un-Ionized Ammonia (UIA), based on Final Chronic Values, Compared to the UIA Concentrations at Increasing Distances from the Point of Discharge.

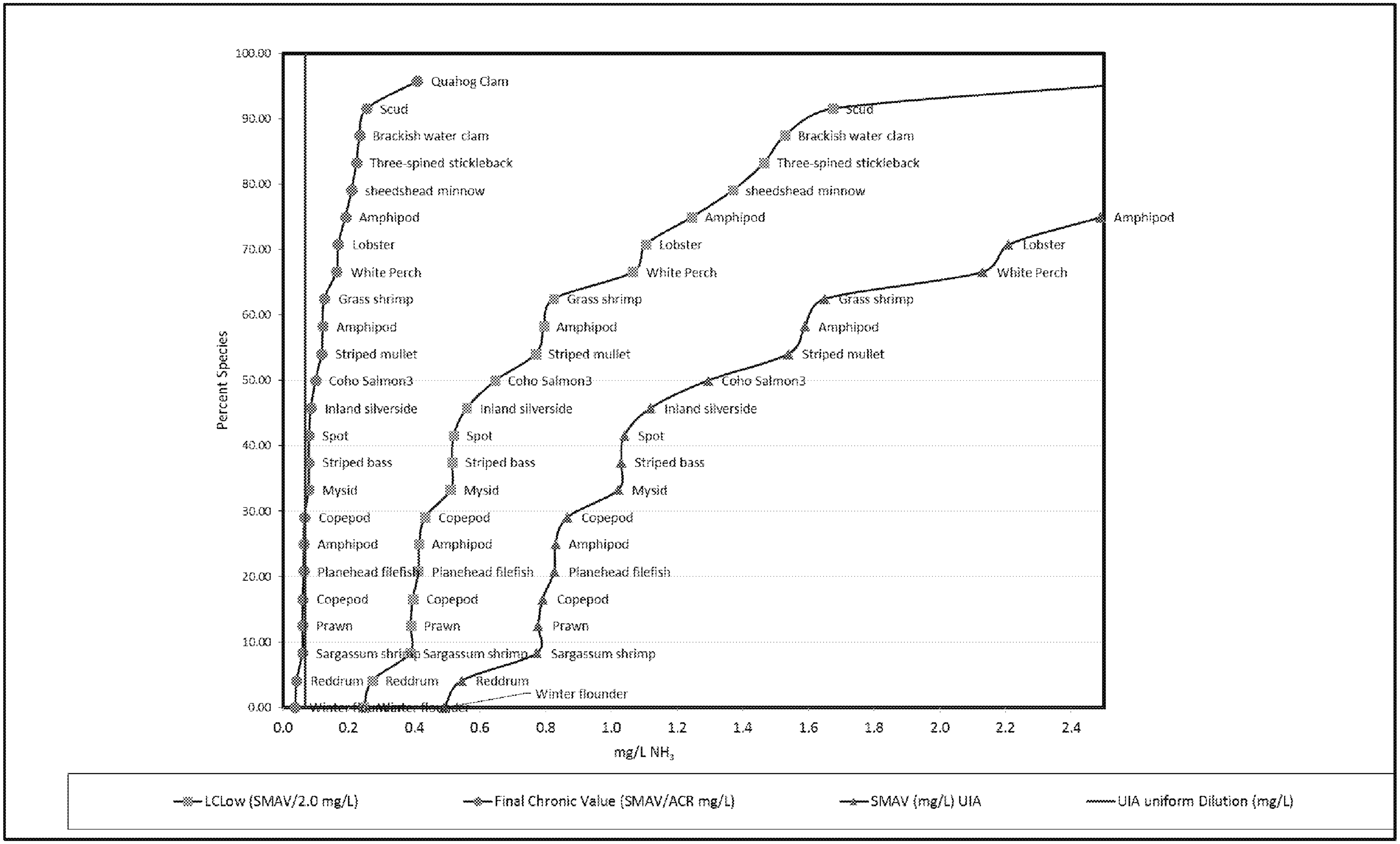

Figure 3.3.8 - Species Sensitivity Distribution for Un-Ionized Ammonia (UIA), based on Acute endpoints and Final Chronic Values, Compared to the UIA Concentration that is Expected to Occur when the WQBEL for UIA (1.2 mg/L) is Diluted by a Factor of 18.

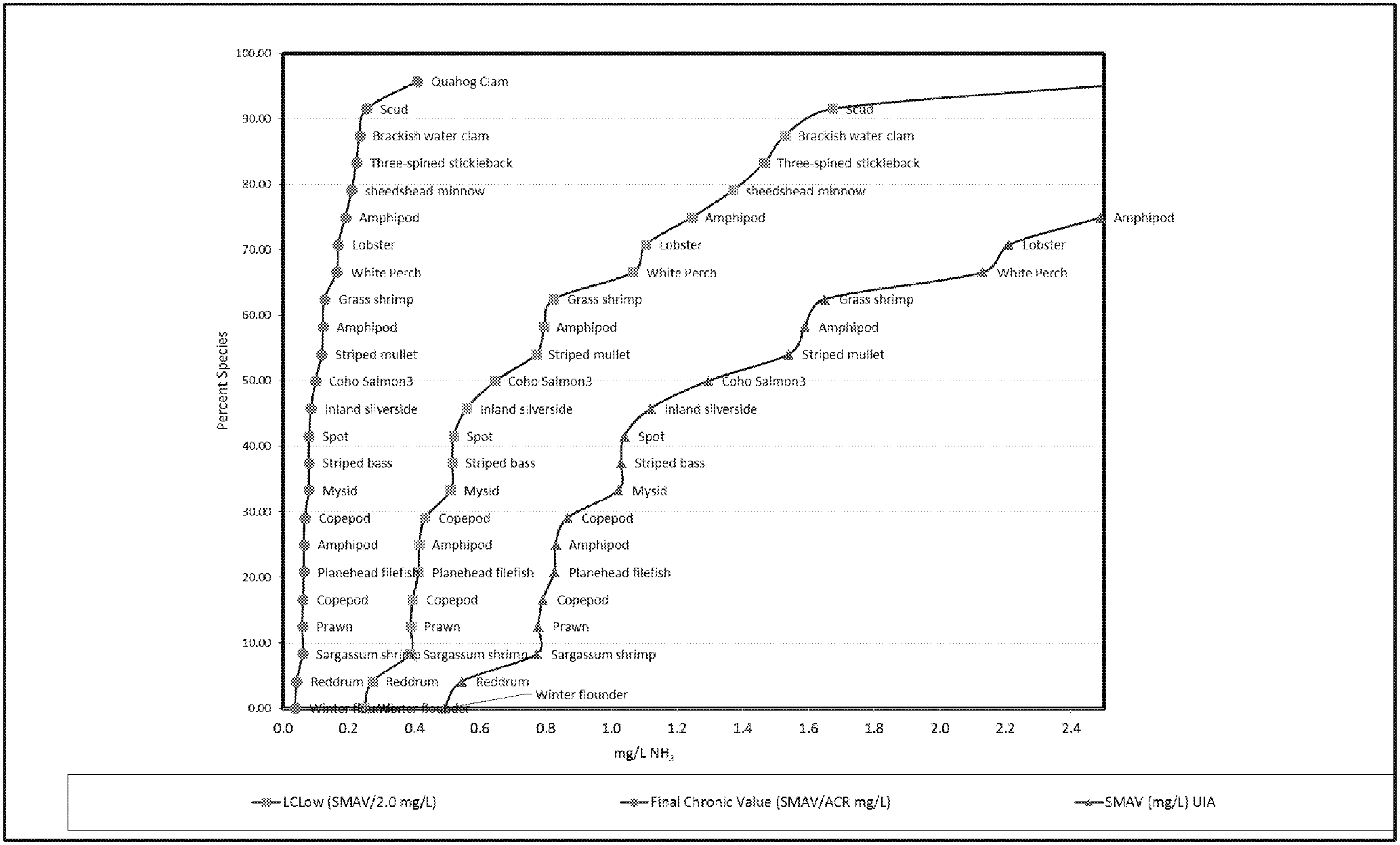

Figure 3.3.9 - Species Sensitivity Distribution for Un-Ionized Ammonia (UIA).

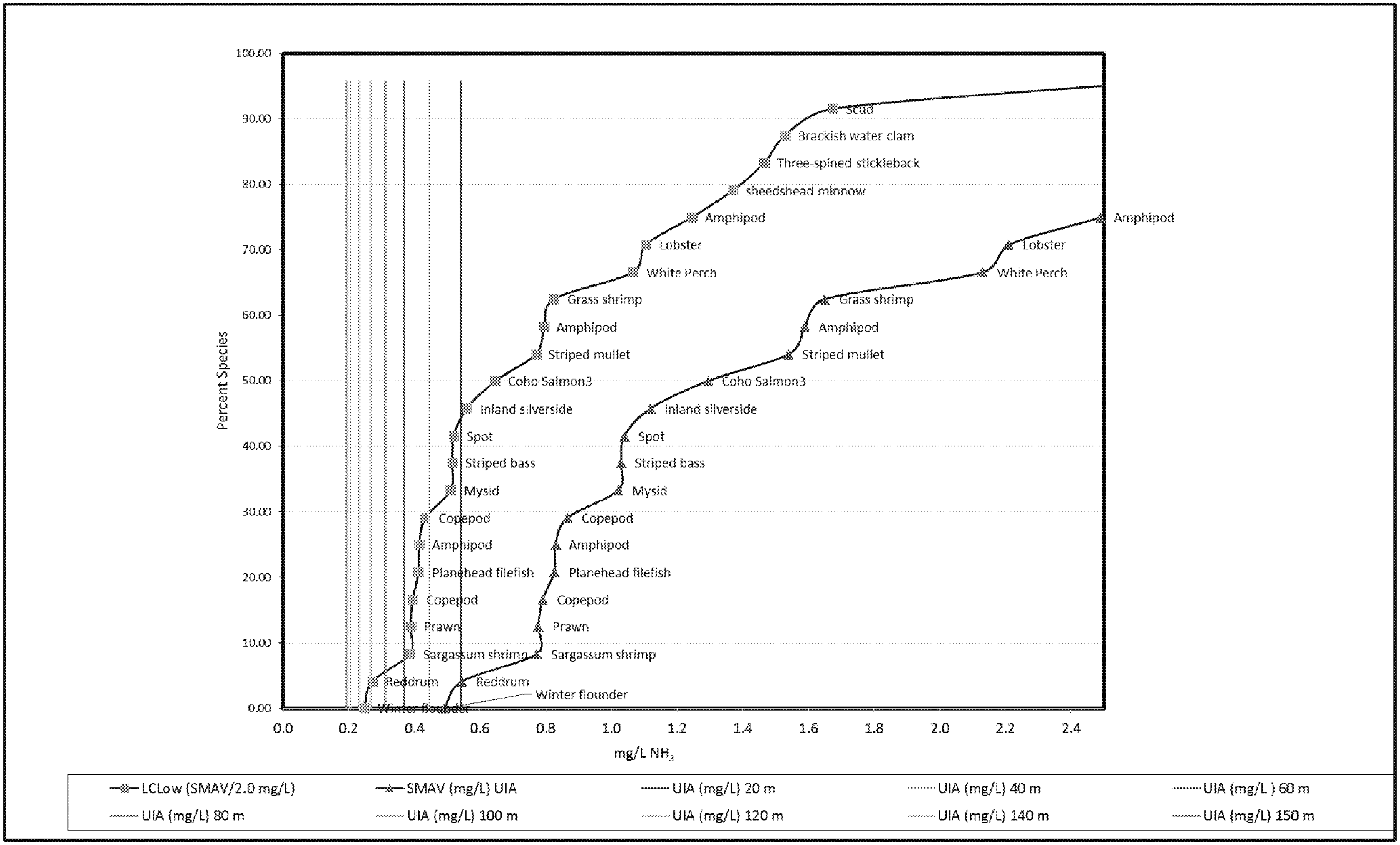

Figure 3.3.10 - Species Sensitivity Distribution for Un-Ionized Ammonia (UIA), based on Acute Effects Endpoints, Compared to the UIA Concentrations at Increasing Distances from the Point of Discharge.

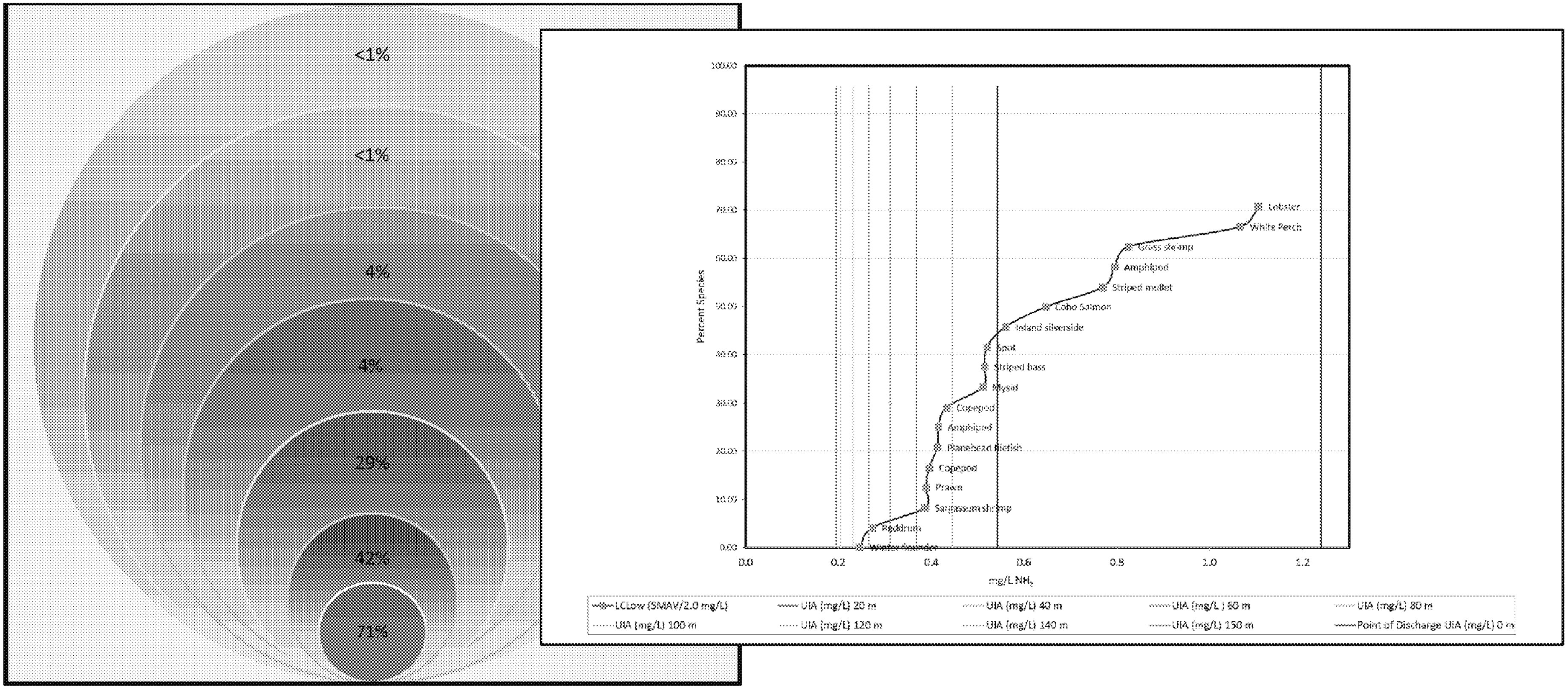

Figure 3.3.11 - Percent of Un-Ionized Ammonia (UIA) Low Level Mortality Concentrations (LC_{Low}) for Individual Species Anticipated to be Exceeded at Various Distances from the Point of Discharge.

Surrogate Species: Yellow perch (Perca flavescens)
Predicted Species: Coho salmon (Oncorhynchus kisutch)

Surrogate Acute Toxicity (log value)	Predicted Acute Toxicity (log value)	
2130 µg/L (3.32)	2140.98 µg/L (3.33)	
Select Confidence Interval:	**Lower Limit**	**Upper Limit**
95%	1292.27 µg/L	3547.07 µg/L

Calculate

Model Information	
Intercept:	0.175215
Slope:	0.948028
Degrees of Freedom (N-2):	17
R^2:	0.961715
p-value:	0.000000
Average value of surrogate (log value):	52.11 (1.71)
Minimum value of surrogate (log value):	0.039999 (-1.39)
Maximum value of surrogate (log value):	13146.99 (4.11)
Mean Square Error (MSE):	0.101330
Sum of Squares (S_{xx}):	48.14
Cross-validation Success (%):	95
Taxonomic Distance:	4

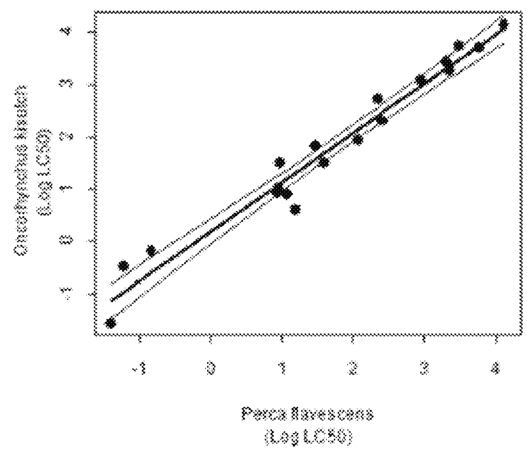

Figure 3.3.12 - Output of EPA Web-Ice Model to Predict an LC50 Values using Surrogate Species.

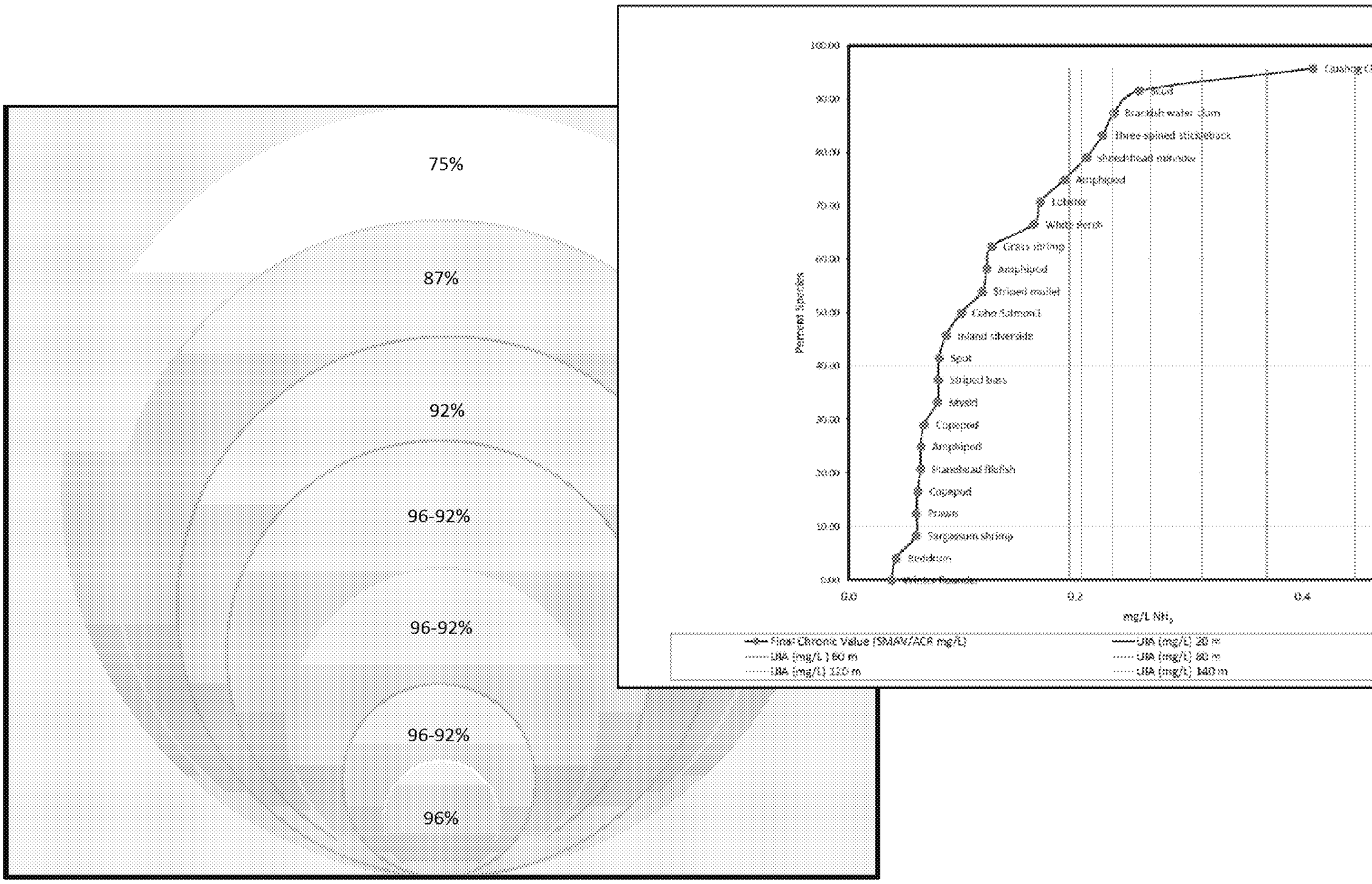

Figure 3.3.13 - Percent of Un-Ionized Ammonia (UIA) Chronic Effects Concentrations (FCV) for Individual Species Anticipated to be Exceeded at Various Distances from the Point of Discharge.

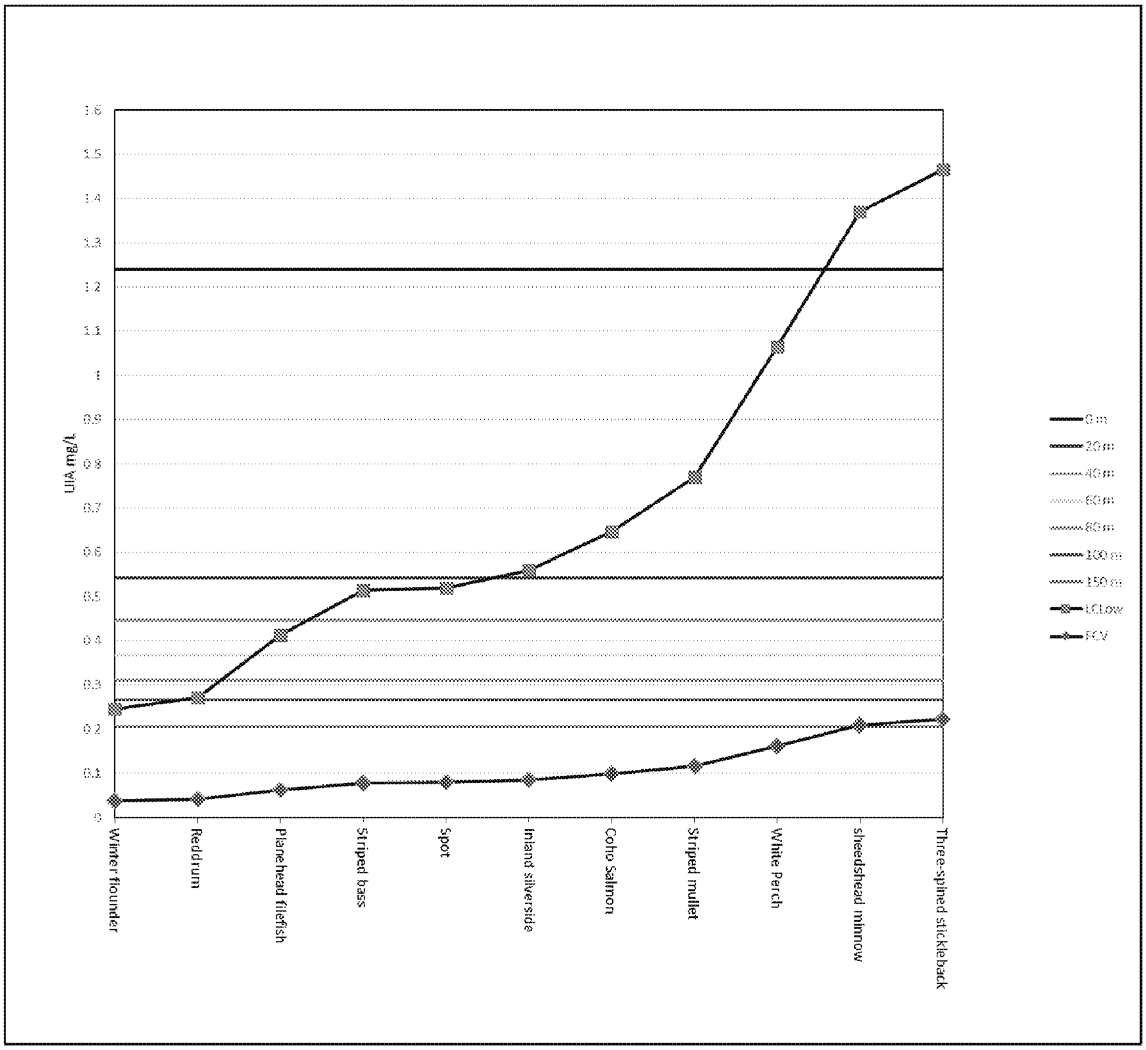

Figure 3.3.14 - The Un-Ionized Ammonia (UIA) LC_{Low} and Final Chronic Values for Fish Species Compared with UIA Concentrations Predicted at 20 Meter Increments from the Point of Discharge for the Kenai WWTP Mixing Zone.

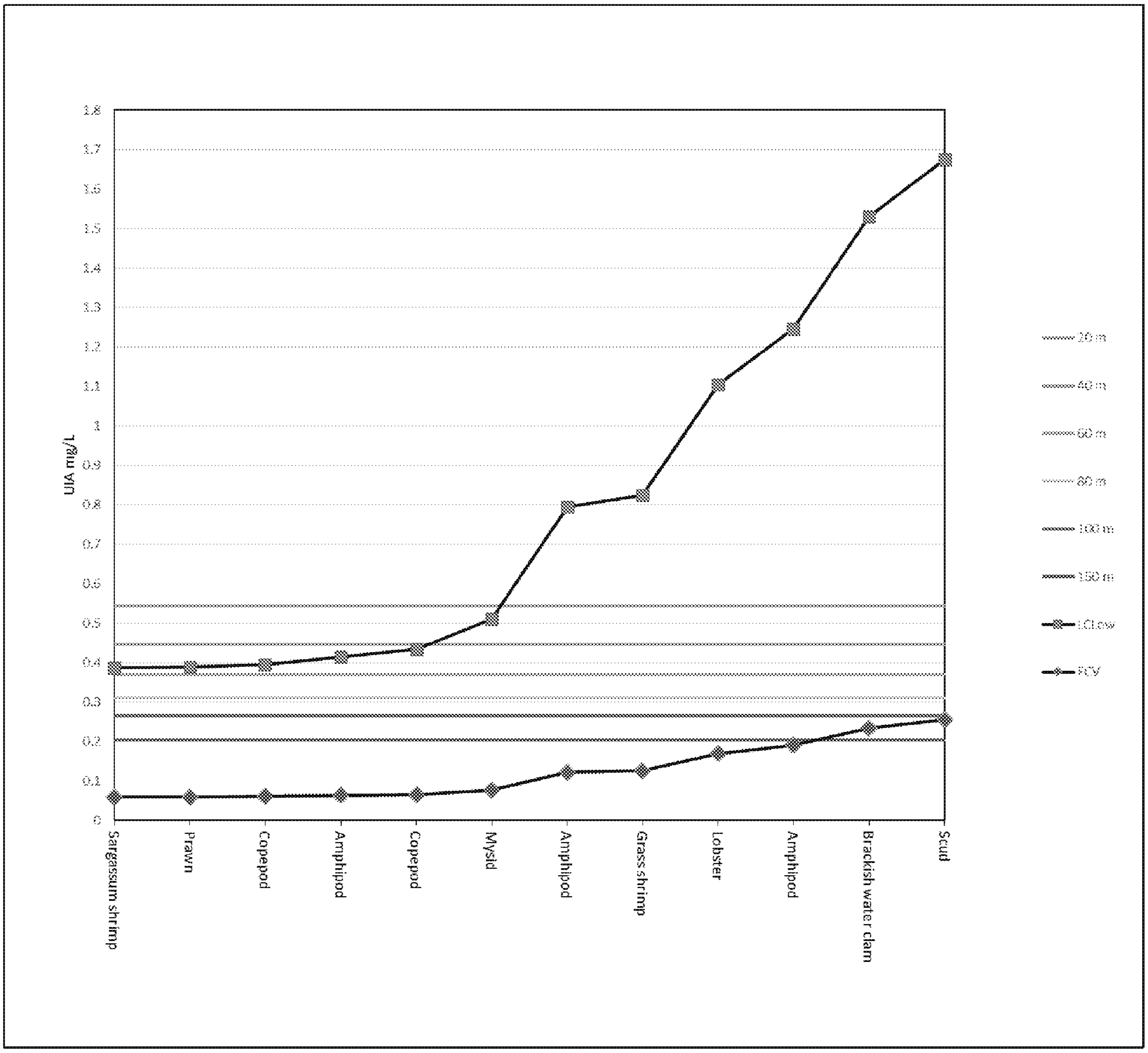

Figure 3.3.15 The Un-Ionized Ammonia (UIA) LC_{Low} and Final Chronic Values for Invertebrates Compared with Concentrations Predicted at 20 Meter Increments from the Point of Discharge for the Kenai WWTP Mixing Zone.

4.0 Summary Discussion of Effects Analysis and Effect Determinations

In the primary effects analysis (Section 3.2), EPA identified potential adverse effects to aquatic life as a result of exceeding water quality criteria within a mixing zone, the PBFs potentially affected by those adverse effects, and provisions of Alaska's revised mixing zone policy that address those effects. For each of the potential stressors or adverse effects identified, EPA has identified provisions of Alaska's revised mixing zone policy that could be implemented to prevent or minimize the effect. In many cases the provisions are specific to the identified effect, i.e., specific to addressing bioaccumulation or toxicity, and in all cases there are general provisions which EPA reads as providing Alaska with broad authority to condition or deny mixing zones as necessary to avoid adverse effects from potential stressors.

Among the provisions of Alaska's revised mixing zone policy identified that could be implemented to prevent or minimize adverse effects were 18 AAC 70.240(c)(4)(D), "the mixing zone will not result in a reduction in fish or shellfish population levels," which provides a clear mandate relevant to protecting the Cook Inlet beluga whale prey species specified in PBF 2; 18 AAC 70.240(c)(F) which speaks to mixing zones and threatened or endangered species, "the mixing zone will not…adversely affect threatened or endangered species except as authorized under 16 U.S.C. 1531 - 1544 (Endangered Species Act);" 18 AAC 70.240 which recognizes that mixing zones are not an entitlement, "The department will approve, approve with conditions, or deny a mixing zone application;" and 18 AAC 70.240(m), which recognizes the potential need to revisit mixing zone decisions to address adverse effects, "If the department finds that available evidence reasonably demonstrates that a mixing zone authorized by the department has had or is having a significant unforeseen adverse environmental effect, the department will terminate, modify, or deny renewal of the permit or certification authorizing the mixing zone."

In the supplemental effects analysis (Section 3.3), EPA uses a mixing zone authorized under Alaska's current mixing zone rule (prior to revision) to illustrate how pollutant concentrations within mixing zones may exceed water quality criteria and thus exceed effects concentrations for certain aquatic species that may be exposed to pollutants within mixing zones. Sessile species, species with small home ranges, and certain juvenile fishes were identified as being most likely to be adversely affected by elevated pollutant concentrations in mixing zones. The juveniles of pelagic beluga whale prey species, such as salmon that remain in the nearshore to rear in the area of mixing zones, may be repeatedly exposed to elevated pollutant concentrations prior to migrating out to sea. EPA also used mixing zones authorized under Alaska's current mixing zone rule (prior to the 2006 revision) to illustrate the effects that mixing zones for certain discharges can have on benthic habitat. Impacts to benthic habitat could adversely affect ground fish beluga whale prey species such as cod and sole.

EPA's effects determinations for the individual PBFs of designated Cook Inlet beluga whale critical habitat are summarized and discussed below. In making its effects determinations, EPA considered the information presented in the primary and supplemental analyses, along with uncertainties associated with implementing mixing zones in a complex hydrodynamic environment such as that of Cook Inlet and the general risk associated with water quality criteria being exceeded in sensitive resource areas such as ESA designated critical habitat.

Effects Determinations for the Physical and Biological Features (PBFs) of Designated Critical Habitat for the Cook Inlet Beluga Whale		
PBF Number	**Description of PBFs from 76 FR 20180**	**Effects Determination**
1	Intertidal and subtidal water of Cook Inlet with depths less than 9.1 m (30 ft) mean lower low water and within 5 miles (8 km) of high and medium flow anadromous fish streams.	Likely to Adversely Affect
2	Primary prey species consisting of four species of Pacific salmon (Chinook, sockeye, chum, and coho), Pacific eulachon, Pacific cod, walleye pollock, saffron cod, and yellowfin sole.	Likely to Adversely Affect
3	Waters free of toxins or other agents of a type and amount harmful to Cook Inlet beluga whales.	Likely to Adversely Affect
4	Unrestricted passage within or between the critical habitat areas.	Not Likely to Adversely Affect
5	Water with in-water noise below levels resulting in the abandonment of critical habitat areas by Cook Inlet beluga whales.	No Effect

In its supplemental effects analysis, EPA also estimated that existing authorized regulatory mixing zones occupy approximately 2 percent or less of the area designated as Cook Inlet beluga whale critical habitat. Beyond considering a possibility that existing mixing zones might be reauthorized under Alaska's revised mixing zone rule and continue to occupy 2 percent of Cook Inlet beluga whale critical habitat, EPA is not able to project the potential magnitude of adverse impacts to PBFs 1, 2 and 3 as a result of EPA's action. Furthermore, there are several factors that could affect the area of Cook Inlet beluga whale designated critical habitat potentially impacted by mixing zones in the future, and thus the accuracy of a 2 percent estimate. These factors include the extent to which future development results in requests to ADEC for new or increased mixing zones and the extent to which adverse effects to PBFs 1, 2 and 3 are authorized under ESA (see language at 18 AAC 70.240(c)(F)). EPA believes that attempting to predict either would be conjecture and, therefore, did not attempt to do so.

PBF 1 - Likely to Adversely Affect

By definition, mixing zones are areas where certain water quality criteria are allowed to be exceeded and thus elevated levels of pollutants are expected to occur. EPA identified provisions of Alaska's revised mixing zone policy that could be implemented to prevent or minimize the authorization of mixing zones in waters designated as critical habitat, or used to minimize the effect on water quality when authorizing mixing zones in such water. Alaska's revised mixing zone rule does not, however, explicitly prohibit mixing zones in the waters of PBF 1. If mixing zones are authorized in the water of Cook Inlet constituting PBF 1, then it is likely that there will be at least some adverse effects to those waters, i.e., elevated pollutant concentrations affecting the water column and benthic habitat, as compared to meeting water quality criteria everywhere. The significance of any adverse effect to water quality in waters of PBF 1 is related to how such effects impact Cook Inlet beluga prey species (PBF 2) and the Cook Inlet beluga itself (PBF 3).

PBF 2 - Likely to Adversely Affect

EPA's primary effects analysis concluded that there are numerous provisions of Alaska's revised mixing zone policy that could be implemented to prevent or minimize adverse effects the Cook Inlets beluga whale designated critical habitat. Among such provisions is 18 AAC 70.240(c)(4)(D), "the mixing zone will not result in a reduction in fish or shellfish population levels" which provides a clear mandate relevant to protecting the Cook Inlet beluga whale prey species specified in PBF 2. However, as stated in the effects determination for PBF 1, Alaska revised mixing zone rule does not explicitly prohibit mixing zones in the waters of PBF 1. If mixing zones are authorized in the water of Cook Inlet constituting PBF 1, then it is likely that there will be some adverse effects to Cook Inlet beluga whale prey species occupying those waters, due to elevated pollutant concentrations affecting the water column and benthic habitat.

EPA's supplemental effects analysis illustrated how pollutant concentrations within mixing zones may exceed water quality criteria and thus exceed effects concentrations for certain aquatic species that may be exposed to pollutants within mixing zones. Sessile species, species with small home ranges, and certain juvenile fishes were identified as being most likely to be adversely affected by elevated pollutant concentrations in mixing zones. While adult salmon and other adult pelagic fish may swim through mixing zones without adequate exposure duration to experience toxic effects, the juveniles of pelagic beluga whale prey species, such as salmon that remain in the nearshore to rear in the area of mixing zones, may be repeatedly exposed to elevated pollutant concentrations prior to migrating out to sea. EPA's supplemental effects analysis also illustrated the effects that mixing zones for certain discharges can have on benthic habitat. Impacts to benthic habitat could adversely affect ground fish beluga whale prey species such as cod and sole.

Furthermore, there is uncertainty as to the net result of implementing provisions such as 18 AAC 70.240(c)(4)(D), "the mixing zone will not result in a reduction in fish or shellfish population levels," and 18 AAC 70.240(c)(F), "the mixing zone will not...adversely affect threatened or endangered species except as authorized under 16 U.S.C. 1531 - 1544 (Endangered Species Act)." While 18 AAC 70.240(c)(4)(D) would seemingly be a basis to protect Cook Inlet beluga prey species from adverse effects, ESA does not necessarily prohibit all adverse effects. Rather, ESA addresses effects at a level that would jeopardize a species continued existence or result in the destruction or adverse modification of the species designated critical habitat. EPA does not have a basis to conclude that there would be no adverse effects to PBE 2 authorized under ESA if EPA approves Alaska's revised mixing zone rule.

EPA also believes that the hydrodynamic information presented for Cook Inlet (Section 2.4) indicates that there could be uncertainty as to whether a particular mixing zone functions as intended, e.g. effluent plume behavior and the dilution that occurs may be different than modeled when a mixing zone is established. This uncertainty is particularly important when authorizing mixing zones in or near sensitive resources such as critical habitat designated under ESA.

For these reasons, EPA determines Likely to Adversely Affect for PBF 2.

PBF 3 - Likely to Adversely Affect

As stated under PBF 1, mixing zones are by definition areas where certain water quality criteria are allowed to be exceeded and thus elevated levels of pollutants, which could include "toxins or other agents" are expected to occur. EPA believes that PBF 3 represents what EPA consulted on for the Cook Inlet beluga whale listing itself in association with EPA's proposed action on Alaska's revised mixing zone rule, i.e., the potential for direct effects of impacts to water quality on Cook Inlet belugas. In that consultation, EPA concluded Likely to Adversely Affect and received a non-jeopardy opinion from NMFS (see Project History Section).

Because EPA had already conducted a consultation effectively addressing PBF 3, EPA, under the advisement of NMFS, looked at indirect effects in its supplemental analysis for this critical habitat consultation. Analysis of indirect effects leads one to looking at prey species; however, the PBFs of critical habitat for the Cook Inlet beluga whale include prey species (PBF 2). Therefore, EPA looked at potential effects to lower trophic level species of the aquatic food web than the fish listed in PBF 2. For reasons related to those used to conclude Likely to Adversely Affect for PBF 1 and PBF 2, EPA also concludes Likely to Adversely Affect for PBF 3. This is consistent with EPA's past determination for the consultation on the Cook Inlet beluga whale species listing.

PBF 4 – Not Likely to Adversely Affect

For the primary effects analysis, EPA considered PBF 4 because conceptually it is possible for mixing zones to affect the movement of aquatic organisms through or within a waterbody, and Alaska's revised mixing zone rule contains a provision explicitly targeted at addressing such potential effects, 18 AAC 70.240(c)(4)(G), "…the mixing zone will not form a barrier to migratory species or fish passage." EPA did not, however, consider PBF 4 in the supplemental analysis because upon conversation with NMFS it was determined that effects to PBF 4 are not a concern in this case. For this reason, EPA determines Not Likely to Adversely Affect for PBF 4.

PBF 5 – No Effect

PBF 5 pertains to noise levels resulting in the abandonment of critical habitat areas by the whales. EPA does not anticipate that approval of the mixing zone rule or the discharges with mixing zones will result in elevated underwater sound. EPA determines No Effect for PBF 5.

Appendix A - Alaska's 2006 Revised Mixing Zone Rule (18 AAC 70.240)

18 AAC 70.240. Mixing zones. (a) Upon application, the department may authorize in a discharge permit or certification, a mixing zone or multiple mixing zones in which the water quality criteria and any limit set under this chapter may be exceeded. The applicant shall provide to the department all available evidence reasonably necessary to demonstrate that a mixing zone will comply with this section. The department will approve, approve with conditions, or deny a mixing zone application.

(b) In determining whether to authorize a mixing zone under this section, the department will consider

(1) the characteristics of the receiving water, including biological, chemical, and physical characteristics such as volume, flow rate, and flushing and mixing characteristics;

(2) the characteristics of the effluent, including volume, flow rate, dispersion, and quality after treatment;

(3) the effects, if any, including cumulative effects of multiple discharges and diffuse, nonpoint source inputs, that the discharge will have on the uses of the receiving water;

(4) any additional measures that would mitigate potential adverse effects to the aquatic resources present; and

(5) any other factors the department finds must be considered to determine whether a mixing zone will comply with this section.

(c) The department will approve a mixing zone, as proposed or with conditions, only if the department finds that available evidence reasonably demonstrates that

(1) an effluent or substance will be treated to remove, reduce, and disperse pollutants, using methods that the department finds to be the most effective, technologically and economically feasible, and at a minimum consistent with statutory and regulatory treatment requirements including

(A) any federal technology-based effluent limitation identified in 40 C.F.R. 122.29 and 40 C.F.R. 125.3, as revised as of July 1, 2005 and adopted by reference;

(B) minimum treatment standards in 18 AAC 72.050; and

(C) any treatment requirement imposed under another state statute or regulation that is more stringent than a requirement of this chapter;

(2) designated and existing uses of the waterbody as a whole will be maintained and protected;

(3) the overall biological integrity of the waterbody will not be impaired; and

(4) the mixing zone will not

(A) result in an acute or chronic toxic effect in the water column, sediments, or biota outside the boundaries of the mixing zone;

(B) create a public health hazard that would preclude or limit existing uses of the waterbody for water supply or contact recreation;

(C) preclude or limit established processing activities or established commercial, sport, personal-use, or subsistence fish and shellfish harvesting;
(D) result in a reduction in fish or shellfish population levels;

(E) result in permanent or irreparable displacement of indigenous organisms;

(F) adversely affect threatened or endangered species except as authorized under 16 U.S.C. 1531 - 1544 (Endangered Species Act); or

(G) form a barrier to migratory species or fish passage.

(d) The department will approve a mixing zone, as proposed or with conditions, only if the department finds that available evidence reasonably demonstrates that within the mixing zone the pollutants discharged will not

(1) bioaccumulate, bioconcentrate, or persist above natural levels in sediments, water, or biota to significantly adverse levels, based on consideration of bioaccumulation and bioconcentration factors, toxicity, and exposure;

(2) present an unacceptable risk to human health from carcinogenic, mutagenic, teratogenic, or other effects as determined using risk assessment methods approved by the department and consistent with 18 AAC 70.025;

(3) settle to form objectionable deposits, except as authorized under 18 AAC 70.210;

(4) produce floating debris, oil, scum and other material in concentrations that form nuisances;

(5) result in undesirable or nuisance aquatic life;

(6) produce objectionable color, taste, or odor in aquatic resources harvested

from the area for human consumption;

(7) cause lethality to passing organisms; or

(8) exceed acute aquatic life criteria at and beyond the boundaries of a smaller initial mixing zone surrounding the outfall, the size of which shall be determined using methods approved by the department.

(e) In lakes, streams, rivers, or other flowing fresh waters, a mixing zone will not be

(1) authorized in a spawning area of any of the five species of anadromous Pacific salmon found in the state; or

(2) allowed to adversely affect the present and future capability of an area to support spawning, incubation, or rearing of any of the five species of anadromous Pacific salmon found in the state.

(f) In lakes, streams, rivers, or other flowing fresh waters, except as provided in (g) of this section, a mixing zone will not be authorized in a spawning area for

(1) Arctic grayling;
(2) northern pike;
(3) lake trout;
(4) brook trout;
(5) sheefish;
(6) burbot;
(7) landlocked coho salmon, chinook salmon, or sockeye salmon; or
(8) anadromous or resident rainbow trout, Arctic char, Dolly Varden, whitefish,or cutthroat trout.

(g) The department may authorize a mixing zone in a spawning area of a lake, stream, river, or other flowing fresh water for the species listed in (f) of this section if

(1) after consultation with the Department of Fish and Game, the department finds that the applicant has demonstrated that the discharge

(A) does not contain pollutants at concentrations that exceed the criteria for growth and propagation of fish, shellfish, other aquatic life, and wildlife established in 18 AAC 70.020(b)(1) - (12); and

(B) will not adversely affect the capability of the area to support future spawning, incubation, and rearing activities;

(2) the applicant has submitted to the department a mitigation plan approved by the Department of Fish and Game under 5 AAC 95.900 if the spawning area is within a special area;

(3) the applicant has submitted to the department a mitigation plan approved by the Department of Fish and Game under AS 16.05.871 – 16.05.901, if the spawning area is within waters included in the *Catalog of Waters Important for Spawning, Rearing or Migration of Anadromous Fishes*, adopted by reference in 5 AAC 95.011; the department will incorporate the mitigation plan as part of the discharge authorization; or

(4) the applicant has submitted to the department a mitigation plan approved by the department, after consultation with the Department of Fish and Game, if the spawning area is not within waters described in (2) or (3) of this subsection; the mitigation plan must use measures described in the *Catalog of Waters Important for Spawning, Rearing or Migration of Anadromous Fishes*, adopted by reference in 5 AAC 95.011; the department will incorporate the mitigation plan as part of the discharge authorization.

(h) In a mixing zone authorization under (g) of this section, the department may require the applicant to monitor effluent, ambient water quality, and biological conditions to determine whether unanticipated adverse effects on spawning, incubation, and rearing of species identified in (f) of this section are occurring.

(i) The provisions of (e), (f), and (g) of this section do not apply to the renewal of a mixing zone authorization where spawning was not occurring at the time of the initial authorization, but successful spawning, incubation, and rearing has occurred within the mixing zone after the initial authorization of that mixing zone.

(j) When determining whether to authorize a mixing zone under (e), (f), or (g) of this section, the department will make that determination

(1) in conformance with the determination of the Department of Fish and Game, acting under AS 16.20, of the location and time of a spawning area within a special area;

(2) in conformance with the determination of the Department of Fish and Game, acting under AS 16.05.871 – 16.05.901, of the location and time of a spawning area within waters included in the *Catalog of Waters Important for Spawning, Rearing or Migration of Anadromous Fishes*, adopted by reference in 5 AAC 95.011; or

(3) after consultation with the Department of Fish and Game, as to what the Department of Fish and Game considers the location and time of a spawning area not within waters described in (1) or (2) of this subsection.

(k) The department will approve a mixing zone, as proposed or with conditions, only if it finds that the mixing zone is as small as practicable and will comply with the following size restrictions, unless the department finds that evidence is sufficient to reasonably demonstrate that these size restrictions can be safely increased:

(1) for estuarine and marine waters, measured at mean lower low water,

(A) the cumulative linear length of all mixing zones intersected on any given cross section of an estuary, inlet, cove, channel, or other marine water may not exceed 10 percent of the total length of that cross section; and

(B) the total horizontal area allocated to all mixing zones at any depth may not exceed 10 percent of the surface area;

(2) for lakes, the total horizontal area allocated to all mixing zones at any depth may not exceed 10 percent of the lake's surface area;

(3) for streams, rivers, or other flowing fresh waters, the length of a mixing zone may not extend beyond the computed point of complete mixing, as determined using a standard river flow mixing model or other methods accepted by the department;

(4) for streams, rivers, or other flowing fresh waters, the length of a mixing zone may not extend downstream beyond the location where the department determines that a public health hazard reasonably could be expected to occur.

(*l*) For streams, rivers, or other flowing fresh waters, in calculating the maximum pollutant discharge limitation, the volume of flow available for dilution must be determined using

(1) the actual flow data collected concurrent with the discharge; or

(2) for conventional and nontoxic substances, the 10-year, 7-day low flow (7Q10) as the criteria design flow; for the protection of aquatic life, the 10-year, 7-day low flow (7Q10) as the chronic criteria design flow and the 10-year, 1-day low flow (1Q10) as the acute criteria design flow; and for the protection of human health, the 5-year, 30-day low flow (30Q5) as the noncarcinogenic criteria design flow and the harmonic mean flow as the carcinogenic criteria design flow; these low flows must be calculated using methods approved by the department.

(m) If the department finds that available evidence reasonably demonstrates that a mixing zone authorized by the department has had or is having a significant unforeseen adverse environmental effect, the department will terminate, modify, or deny renewal of the permit or certification authorizing the mixing zone.

(n) When consulting with an agency under (g) or (j) of this section, the department will give appropriate weight to any information received from the agency, considering the agency's expertise.

(o) For purposes of this section, the five species of anadromous Pacific salmon found in the state are chinook salmon, coho salmon, sockeye salmon, pink salmon, and chum salmon.

(p) In this section, "special area" means a state game refuge, a state game sanctuary, or a state fish and game critical habitat area, established under AS 16.20. (Eff. 11/1/97, Register 143; am 3/23/2006, Register 177)

Authority: AS 46.03.010, AS 46.03.080, AS 46.03.720, AS 46.03.020, AS 46.03.100, AS 46.03.050, AS 46.03.110, AS 46.03.070, AS 46.03.710

Editor's note: As of Register 186 (July 2008), and acting under AS 44.62.125(b)(6), the regulation attorney made a technical change to 18 AAC 70.240(g) and (j), to reflect Executive Order 114 (2008). Executive Order 114 transferred functions related to protection of fish habitat in rivers, lakes and streams from the Department of Natural Resources to the Department of Fish and Game.

18 AAC 70.245. Mixing zones: appropriateness and size determination. Repealed. (11/1/97, Register 143; repealed 3/23/2006, Register 177)

18 AAC 70.250. Mixing zones: general conditions. Repealed. (Eff. 11/1/97, Register 143; repealed 3/23/2006, Register 177)

18 AAC 70.255. Mixing zones: in-zone quality and size specifications. Repealed. (Eff. 1/1/97, Register 143; repealed 3/23/2006, Register 177)

18 AAC 70.260. Mixing zones: application requirements. Repealed (Eff. 11/1/97, Register 143; repealed 3/23/2006, Register 177)

18 AAC 70.270. Mixing zones: termination, modification, or denial of renewal. Repealed. (Eff. 11/1/97, Register 143; repealed 3/232/2006, Register 177)

Appendix B - List of Cook Inlet Point Source Discharges with Mixing Zones

(Please see spreadsheet provided electronically "Cook Inlet Point Source Discharges with Mixing Zones")